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ART. I.—On some New Australian Chrysomelidae (Coleoptera).

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[Read 13th March, 1924.]

The species here dealt with all belong to the subfamily Galerucides, and *Rupilia* and *Necorupilia* are especially interesting, as their elytra are abbreviated, so that much of the upper surface of the abdomen is exposed.

EILOPIA AMPLIPENNIS, sp. nov.

♂. Flavous, elytra deep blue, or greenish-blue, abdomen (except tip), parts of antennae and of legs, and spots on head and prothorax black or infuscated.

Head irregular and with dense punctures between eyes, with sparse punctures elsewhere. Antennae moderately long, fourth joint distinctly longer than second or fifth, and about twice the length of second. Prothorax twice as wide as long, sides straight, except at angles, base, apex and sides margined; surface slightly uneven, and finely shagreened, with numerous, rather small punctures, becoming crowded in front angles. Scutellum with small punctures. Elytra strongly convex, dilated to beyond the middle, where the width is fully twice that of the prothorax; with rather dense, sharply defined punctures of moderate size, and denser smaller ones. Legs stout; claws strongly appendiculate. Length, 8–11 mm.

♀. Differs in having much wider elytra, shorter antennae, and thinner legs, with basal joint of tarsi smaller.

Hab.—New South Wales: Jenolan (J. C. Wiburd and A. M. Lea); Ben Lomond, 4500 feet (Dr. A. J. Turner); Queanbeyan (Lea).

Readily distinguished from *E. pedestris* and *E. sloanei* by the elytra. At first glance it appears to belong to *Oides*, but wings are completely absent. On the head there are usually two large sub-basal spots, but on one specimen they are conjoined to form a transverse oblong at the base; on the pronotum there are usually four spots across the middle of which the two inner ones are smaller than the others, and sometimes faint; on one of the Ben Lomond specimens there is an additional spot near each side; on the Queanbeyan specimen the prothorax is immaculate. Seven or eight joints of the antennae are entirely dark, the others are partly or entirely pale; the pale parts of the legs are the coxae, femora and base of tibiae.

ELLOPIA LATA, sp. nov.

♂. Black, elytra with a coppery or bronzy gloss; front of head prothorax (some black markings excepted), scutellum, tip of abdomen, coxae, knees, and parts of four basal joints of antennae flavous.

• Head shagreened, and with distinct punctures on basal half. Antennae moderately long, seventh joint subtriangularly produced on one side of apex, third and fourth subequal. Prothorax twice as wide as long, sides gently rounded, and rather widely margined, the base and apex finely margined; surface slightly uneven, and with sharply defined but not very dense punctures. Scutellum slightly convex and with small punctures. Elytra dilated to beyond the middle, where the width is about twice that of the prothorax; marginal gutters rather wide, tips strongly separately rounded; surface uneven and shagreened; with fairly numerous but not very large punctures, slightly larger than prothorax. Claws each with a subangulate basal appendix. Length, 7-11 mm.

♀. Differs in having much wider elytra and abdomen, somewhat shorter legs and antennae, and the latter with the seventh joint less produced on one side.

Hab.—New South Wales: Brewarrina, in November; Pera Bore in August (W. W. Froggatt, No. 15); Bourke (— Muf-
fens); Gosford (H. W. Brown).

The outer edges of the elytra are curved up so as to simulate epipleurae, but they are not such. This, with the comparatively feeble punctures of elytra, and certain resemblances to *E. slounei*, caused me to refer the species to *Ellopia*, rather than to *Rupilia*, although the partly exposed abdomen and seventh joint of antennae seems to be more distinctive of the latter genus. The black parts of the prothorax are the margins, an irregular blotch towards each side (sometimes connected with it), and a small rounded medium spot (within a depression) near the base. Of the seven specimens under examination the median line of the head is faintly impressed towards the base on six, on the other it is deep and wide there, but this may be accidental.

RUPILIA.

The two original species of this genus, *R. viridis* and *R. viridiaenea*, were described as from New South Wales, but probably in error; there are also some curious points in the descriptions; the former was noted as having the elytra "*nigro-caeruleis*," but they were figured as green shading off to blue; on some specimens that appear to belong to the species (taken at Tennant's Creek by Mr. J. F. Field) they are blue (in some lights with a greenish gloss), shading off to purple. *R. viridiaenea* was described as "*nigro-aenea*,"; green, except by its equivalent in the name itself, being nowhere mentioned. The sexes of most species of the genus may be at once distinguished by the seventh joint of the

RUPILIA RUGULOSA, Blackb.

A specimen from the Herbert River (Queensland), probably belongs to this species, but differs from the description in having a large infuscation on the disc of the pronotum; its abdomen has the apical segment, and the base of each of the others pale; the elytral epipleurae are fairly wide at the base, but taper gradually to their termination. Three other specimens, from Bowen, have the elytra more brightly coloured (deep violet on two males, purplish-blue on a female), but with the discal infuscation of the pronotum smaller, and less pronounced. One from Cairns has the suture, tips, and apical sides of elytra obscurely diluted with red. All five specimens have the laterobasal parts of the head more or less infuscated or blackish.

The species is evidently allied to *R. viridiuena* (the Bowen specimens were, in fact, so named in the Simson collection), but it differs from the description in having the prothorax mostly reddish, certainly not "*antice et postice tenuiter rufo-fusco*," front of head, metasternum, part of each abdominal segment, part of antennae, and sometimes parts of legs reddish; the head also could not fairly be described as transversely foveolate between the eyes.

RUPILIA INSIGNIS, sp. nov.

♂. Bright reddish-castaneous, elytra partly blue, parts of antennae, of tibiae, and of tarsi blackish. Upper surface, except of abdomen, glabrous.

Head with a longitudinal impression at base, a fovea between bases of antennae, sides punctate, and strigose. Antennae rather stout, third joint about twice the length of second, and slightly longer than fourth, seventh slightly produced on one side of apex, slightly shorter than sixth, and longer than eighth. Prothorax about one-fourth wider than long angles rounded off sides parallel between them, middle of apex gently incurved; a rather deep transverse groove slightly in advance of middle, and a shallow irregular one near base; punctures fairly dense and distinct in front angles, sparser and smaller elsewhere. Scutellum convex posteriorly, and with a few small punctures. Elytra about twice the length of prothorax, and beyond middle about twice the width; surface uneven, and with crowded and rather large punctures. Claws each with an acute appendix. Length, 8.5–12.5 mm.

♀. Differs in having elytra and abdomen considerably wider, seventh joint of antennae scarcely produced on one side, and basal joint of tarsi smaller.

Hab.—Northern Territory: Tennant's Creek (J. F. Field); North-Western Australia: Derby (W. D. Dodd).

The pale portion on the elytra occupies the sutural half for about the basal fourth, it is then suddenly dilated to near the sides, to terminate near the apex, so that it appears as a trilobed space, margined, except about the scutellum, with blue; on one specimen

the pale portion is also connected with the base of each elytron by a narrow line near the shoulders. On the Derby specimens the pale portion occupies much less space than on the others, but it is still trilobed. The sides of the elytra are curved around, so as to slightly embrace the abdomen, but the epipleurae are very narrow and inconspicuous; most of the abdomen is exposed on both sexes.

RUPILIA SUTURALIS, sp. nov.

♂. Flavo-castaneous, elytra dark metallic green, or blue, or purple, a pale sutural vitta occupying about half of the base, but evenly narrowed to apex; most of antennae and of legs black, four dorsal segments of abdomen each with a large black or infuscated spot on each side. Upper surface, except of abdomen, glabrous.

Head with an impressed median line from base to clypeus, somewhat dilated between antennae; a few large punctures near antennae, but elsewhere small. Antennae rather long and thin, third joint about twice the length of second, apex of seventh conspicuously curved inwards. Prothorax about one-third wider than long, angles rounded off, the sides between them almost parallel; a wide, deep and irregular transverse impression interrupted in middle, between it and base somewhat uneven; with a wide shallow interrupted longitudinal impression; punctures dense and irregular. Scutellum with a few irregular punctures. Elytra more than twice the length, and near apex about twice the width or prothorax, surface uneven, and with large crowded punctures sometimes confluent, epipleurae rather narrow at base, and evenly narrowed to apex. Claws each with a large acute appendix. Length, 7–11 mm.

♀. Differs in having considerably wider elytra and abdomen, the latter with the apical segment rounded at the tip, instead of incurved, prothorax with the sides somewhat narrowed posteriorly, antennae shorter, with the seventh joint simple, and basal joint of tarsi slightly smaller.

Hab.—Northern Territory: Darwin (N. Davies); Groote Eylandt (N. B. Tindale).

Evidently allied to *R. excelsa*, but differs from the description in the sculpture of prothorax and scutellum. On some females parts of the under surface of abdomen are infuscated. The only specimen from the island is a small male, and has somewhat longer and thinner antennae, and its prothoracic impressions are slightly deeper than on the other males, but otherwise it agrees well with them. About half of the abdomen is exposed on both sexes.

RUPILIA CAVICOLLIS, sp. nov.

♂. Bright flavo-castaneous, elytra violet-blue, except for a wide sutural vitta narrowed posteriorly, most of antennae and of legs black, abdomen with infuscations towards the sides on the

upper surface, at the base of the segments, on the lower surface. Upper surface, except of abdomen, glabrous.

Head with a median line from base to clypeus, in parts dilated; rugose and irregularly punctate about antennae, rather smooth elsewhere. Antennae moderately long, third joint not quite twice the length of second, seventh conspicuously produced on one side of apex. Prothorax not much wider than long, base apex and sides incurved to middle, a rather deep interrupted median line, a wide, deep, irregular impression from near middle to each side, and a smaller one on each side of base; punctures rather large and dense about front angles, sparse elsewhere. Scutellum grooved near apex and bilobed there, with a few punctures. Elytra more than twice the length of prothorax, and almost twice the width in the middle, sides gently rounded, a distinct groove near each side from near base almost to apex; punctures dense and rather coarse; epipleurae very narrow and concealed almost from the sides. Claws each with an acute and rather small appendix. Length, 8-10 mm.

Hab. Queensland: Cloncurry (H. Hacker).

Evidently close in appearance to *R. excelsa*, but differs from the description in punctures of head prothorax and scutellum, in the prothorax having a rather deep longitudinal line (although interrupted in middle), and in the conspicuous sublateral depressions on elytra. Its colours are much as on *R. suturalis*, but the prothorax scutellum, and elytra are differently sculptured. Each side of the prothorax, from an oblique direction, appears rather strongly notched. On the type the blue of the elytra is uniform, but on a second specimen it has a greenish gloss in parts. More than half of the abdomen is exposed.

RUPILIA VIRIDIPENNIS, sp. nov.

♂. Dark red, elytra metallic coppery-green, changing to bluish on the sides and apex, sterna, coxae, femora, and base of tibiae flavous, rest of the legs, abdomen and most of antennae black.

Head with two small, subtriangular, rugose, inter-ocular spaces, behind them with coarse, crowded punctures. Antennae moderately long, third joint more than twice the length of second, seventh conspicuously produced on one side of apex. Prothorax almost twice as wide as long, sides obtusely produced in middle, a wide depression across middle deepened towards each side; punctures dense and coarse as on base of head. Scutellum truncated posteriorly, with distinct punctures. Elytra about five times the length of prothorax, and beyond middle fully twice as wide, sides strongly dilated posteriorly, the apices gently separately rounded; punctures coarse, crowded and in places confluent; epipleurae gently concave and conspicuous, although not very wide, from base to apex. Each claw with an acute appendix. Length, 7.5 mm.

Hab.—New South Wales: Jenolan (J. C. Wiburd).

The elytra almost cover the abdomen, and are without a wide triangular notch at the apex, but as their epipleurae, as seen from below, are conspicuous and the upper surface is coarsely punctate, the species was referred to *Rupilia*, rather than to *Ellopia*, the only other apterous genus to which it could be referred. From the sides the elytral punctures are seen to be feebly pubescent. The general appearance is somewhat like that of *Hoplostines viridipennis*, on an enlarged scale, but that species is winged.

RUPILIA CRIBRATA, sp. nov.

♂. Flavous, black and purple.

Head with a median line from base to apex, a conspicuous bisinuate line between eyes; with dense and coarse punctures on basal half. Prothorax across middle twice as wide as long, apex gently incurved to middle, base straight, sides angulate in middle, front angles acutely produced; surface uneven and with coarse, crowded punctures. Scutellum wide, with a few large punctures. Elytra almost four times the length of prothorax, and almost twice as wide as their widest part (about one-third from apex), tips feebly separately rounded, sides strongly margined; punctures dense and coarse; epipleurae distinct and parallel-sided from base almost to apex. Abdomen with a semi-circular apical notch. Claws acutely appendiculate. Length, 7.5 mm.

Hab.—Northern Territory (J. P. Tepper).

The antennae are missing from the types, but it has been described as it is a very distinct species, quite evidently a *Rupilia*, and connects *R. viridipennis* with the more typical species of the genus. The elytra cover the abdomen except for part of the pygidium. In general appearance it is like a species identified with some doubt as *R. rugulosa*, but the elytral epipleurae are parallel-sided almost throughout; from *R. impressa* and *R. ruficollis* it is readily distinguished by the angulated sides of prothorax. The flavous parts are the upper surface of head (except at sides and base), prothorax, scutellum, sterna, part of apical segment of abdomen and coxae; the black parts are the rest of the head, legs and abdomen, the latter in parts has a purplish gloss; the elytra are entirely deep purple; subopaque on the upper surface, with the epipleurae shining.

RUPILIA TRICOLOR, sp. nov.

♂. Reddish, elytra purple, antennae (except parts of three basal joints), and legs (except coxae and base of femora), black. Upper surface, except of abdomen, glabrous.

Head with a continuous median line, a transverse bisinuate one between eyes; punctures sparse and irregularly distributed. Antennae moderately long, third joint almost twice the length of second, seventh conspicuously curved to one side at apex. Prothorax about once and one-third as wide as long, base and apex slightly, the sides strongly incurved to middle; a deep transverse

impression slightly nearer apex than base, but interrupted in middle by the low walls of a longitudinal impression, the latter deeper behind than in front, base uneven; with fairly dense punctures about front angles, sparse and irregular elsewhere. Scutellum almost truncated at apex. Elytra almost thrice the length of prothorax, and almost thrice as wide at their widest part (slightly beyond the middle), surface uneven, and with dense and rather strong punctures. Claws acutely appendiculate. Length, 12 mm.

Hab.—North-Western Australia: Wyndham (— Stephens).

Close to *R. impressa*, but sides of prothorax quite strongly incurved to middle; about the base there are six slight and not completely free elevations due to the impressions; the prothorax grooved along middle and narrowest at the middle of the sides distinguish from the description of *R. brevipennis*. The elytra leave three dorsal segments completely exposed, and the median parts of the others, their sides are curved to slightly embrace the abdomen, and their epipleuræ are very narrow and concealed.

RUPILIA MICROPTERA, sp. nov.

♀. Deep black, prothorax sterna and coxæ of a dingy testaceous, elytra obscurely purplish, in parts greenish.

Head with a median line, becoming foveate between antennæ, front of forehead shining and with sharply defined punctures, elsewhere mostly subopaque and shagreened. Antennæ rather short and stout, third joint not quite twice the length of the second, its apex and that of the seventh wider than any of the others. Prothorax shining, about once and one-third as wide as long, base and apex gently incurved to middle, all angles obtusely dentate, sides angulate in middle; a large depression towards each side, each with two basal extensions, median line shallow and confined to apical half; with a few distinct punctures about sides, but elsewhere almost impunctate. Scutellum wide, shining, and with minute punctures. Elytra very small, strongly narrowed from near base to apex, shagreened, opaque, and with rugose, and not very large punctures. Length, 9 mm.

Hab.—South Australia: North-Eastern Corner (F. Parsons).

The elytra are decidedly smaller than those of any previously described species, each has an area about equal to that of the prothorax, their tips do not extend to the apex of the first abdominal segment, and the triangular notch between them extends almost to the base; their epipleuræ, however, are quite distinct. On the type there is a large infuscation on the disc of the pronotum, but it appears to be due to decomposition. From most directions the claws appear to be quite simple, but each has an appendix closely applied to it.

NEORUPILIA.

To this genus of curious little insects with aborted wings and abbreviated elytra, two new species can now be added; with the previously known ones they may be distinguished as follows:—

Elytra with sharply defined markings.

Each humeral spot large and touching the margin *ornata*.

Each humeral spot thin, curved and not touching the margin *humeralis*.

Elytra uniformly coloured.

Elytra flavous *flava*.

Elytra green or greenish.

Prothorax also green *viridis*.

Prothorax flavous *stirlingi*.

NEORUPILIA FLAVA, sp. nov.

Pale castaneo-flavous, seven or eight apical joints of antennae partly or entirely infuscated. Elytra with sparse, semi-erect setae, or thin pubescence.

Head of moderate size, interocular groove narrow and almost straight, a narrow impression in front of its middle; punctures inconspicuous. Eyes small and prominent. Antennae moderately thin, third joint very slightly longer than second, and slightly shorter than fourth. Prothorax about once and one-third as wide as long, sides gently rounded and finely margined; punctures sharply defined, but rather small. Elytra subelliptic, widest slightly beyond middle, leaving part of abdomen exposed; with dense, sharply defined punctures, larger than on prothorax; epipleurae narrow posteriorly but traceable to apex. Length, 2·25 mm.

Hab.—Tasmania: Hobart, Huon River (A. M. Lea); West Tamar (Aug. Simson).

The pale elytra readily distinguish this species from all previously known ones; on one specimen the abdomen is infuscated, on several others its sides and the sides of the prothorax are faintly so, but the parts named are usually of exactly the same shade as the adjoining ones. At first glance it looks like a small pale *Monolepta*, but the exposed abdomen and aborted wings are distinctive from that genus.

NEORUPILIA HUMERALIS, sp. nov.

Black, prothorax (in parts infuscated), scutellum, elytral markings, legs (in parts infuscated), and three or four basal joints of antennae more or less flavous. Upper surface glabrous.

Head of moderate size, interocular groove curved slightly forwards, punctures inconspicuous. Eyes rather small. Antennae not very thin, second and third joints subequal, their combined length distinctly more than first or fourth. Prothorax about once and two-thirds as wide as long, lateral and basal margins distinct; a few rather large punctures in front angles, elsewhere minute but fairly numerous. Elytra subelliptic, leaving tips of abdomen exposed; punctures moderately dense, and sharply defined, even posteriorly; epipleurae very narrow posteriorly, but traceable almost to suture. Length, 2·5 mm.

Hab.—South Australia: Lucindale (F. Secker), Mount Gambier (A. M. Lea).

The antennae are stouter than in the previously named species; the elytral markings are very different from those of *N. ornata*, the only other one with distinct spots. The type has obscure infuscations on the sides and middle of the pronotum; each elytron has a narrow, curved, flavous mark on the shoulder, the one on the right being)-shaped; beyond the middle there is a narrow transverse spot, and the tip and epipleura are also narrowly flavous. On the specimen from Mount Gambier most of the pronotum is deeply infuscated, leaving two flavous vittae; on its elytra the humeral and apical markings are larger, and the postmedian spot is broken up into two of which the inner one is obscurely connected with the humeral one.

OIDES.

The Australian species of this genus may usually be distinguished by their colours and markings, although both are sometimes variable. Being soft-bodied the abdomen is especially liable to postmortem contraction, the impressions on the pronotum also vary in extent from the same cause. The species before me may be thus distinguished:—

- A. Prothorax not entirely pale.
 - a. Prothorax with large black blotch *dorsosignata*.
 - aa. Prothorax with two small blackish spots *bimaculicollis*.
- AA. Prothorax entirely pale.
 - B. Elytra entirely pale *antennalis*.
plantarum.
- BB. Elytra partly dark.
 - C. Elytra narrowly pale only at the sides and suture.
 - b. Suture conspicuously pale, form narrow *soror*.
 - bb. Suture obscurely or not at all pale, form robust *laetabilis*.
 - CC. Elytra with a conspicuous 3-shaped apical mark *arithmetica*.
 - CCC. Elytra with a black oblong patch on each
 - CCCC. Elytra with spots.
 - c. The spots six in number *sexmaculipennis*.
 - cc. The spots four in number.
 - d. Antennae entirely pale, spots black *albertisi*.
 - dd. Antennae partly black, spots purplish *continentalis*.
 - CCCCC. Elytra vittate.
 - D. One dark vitta on each elytron.
 - e. Elytra highly polished and not shagreened *polita*.
 - ee. Elytra finely shagreened and subopaque.
 - f. Elytral vittae distinctly dilated posteriorly *variivitta*.
 - ff. Elytral vittae scarcely, if at all, dilated posteriorly *silphomorphoides*.
 - DD. Two dark vittae on each elytron *fryi*.
 - DDD. Three on each *sexvittata*.
 - DDDD. Four on each *tigrina*.

Notes on Above Table.

B. There are two species before me having the upper surface entirely pale, but two specimens identified by Blackburn as *O. antennalis*, I cannot distinguish from the co-types of *O. plantarum* with certainty, and they do not agree as well with Baly's description as another specimen identified as *O. antennalis*, so the two names should probably not be regarded as synonymous.

Of the four species not included in the table, *O. seminigra* should be associated with *O. dorsosignata*, but has two vittae, conjoined posteriorly, on each elytron; *O. ovatipennis* should be associated with *O. bimaculicollis*, but only the suture and sides of the elytra are narrowly pale; *O. velata* is evidently allied to *O. albertisi* and *O. continentalis*; for comments upon it, see under the latter species; for comments upon *O. quinquelineata*, see under *O. sexvittata*.

OIDES LAETABILIS, Clark.

O. CIRCUMDATA, Baly, n.pr.

The elytra of *O. circumdata*, Baly, were originally described as olivaceous, with the margins narrowly pale, the type was probably immature, as the usual colour of the elytra is deep blue (occasionally they have a coppery gloss), the margins are very narrowly pale, the pale part sometimes slightly extended near the shoulders, and occasionally interrupted at apex; rarely the suture is obscurely diluted with red. From a specimen in better condition the species was subsequently named *O. lactabilis* by Clark¹, reference to the name being omitted from Masters' Catalogue; but as there was previously an ex-Australian *O. circumdata*,² the name *O. lactabilis* must stand for the Australian species.

OIDES SEXVITTATA, Duviv.

Four specimens, from Cairns and the Endeavour River, probably belong to this species; each has three black vittae on each elytron, free at both base and apex, the first not touching the suture, and on two specimens rather vaguely defined in the middle, the outer vitta usually wider than the others. The species is decidedly close to *O. tigrina*, but that species has four vittae, conjoined posteriorly, on each elytron. From comparison of the types Duvivier believed that *O. quinquelineata* belongs to the species, but judging by the description it is at least worthy of a varietal name, as there are but two free vittae on each elytron and a wide sutural one common to both.

OIDES SILPHOMORPHOIDES, Blackb.

On the type and other specimens from the Northern Territory (Darwin and Pine Creek), the dark vittae on the elytra of

1. Clark, Journ. Ent., II, p. 259.

2. Montrouzier, Ann. Soc. Agr. Linn. Lyon, 1887, p. 72.

this species commence close to the base, and terminate near the apex; they are almost parallel-sided throughout, and parallel with each other, except for a slight posterior curvature; they are black or blackish, with, at most, a faint purplish gloss.

Var. A. Numerous specimens, from Darwin, and the King River, may be regarded as representing a variety; they differ from the typical form in having the vittae with a more purplish (rarely greenish) gloss, commencing at the base itself, slightly more dilated towards the apex, with their apices curved round, as a result the elytra appear to have a large U, the parts outside the vittae are conspicuously paler than the inner parts; the elytral punctures are also usually smaller than those of the typical form, although they vary on both forms.

OIDES SOROR, Blackb.

The general appearance of this species is much like that of a large *Calomela*, of the style of *C. curtisi*; its elytra are much narrower than those of *O. lactabilis*, and it is otherwise very distinct from that species. There are two specimens before me, the type and one from Roebuck Bay.

OIDES FRYI, Clark.

O. INSIGNIPENNIS, Blackb., var.

O. OCULARIS, Blackb., var.

O. IGNOTA, Blackb., var.

This species occurs from Dorriggo, in New South Wales, to Cairns, in Queensland; it varies in the width and intensity of the dark elytral vittae, in the dark parts of the antennae, in the punctures of elytra and pronotum, and in the transverse impressions of the latter. *O. insignipennis*, *O. ocularis*, and *O. ignota* appear to be varieties of it. Blackburn made no allowance for sexual and individual variation.

Var. OBSOLETA, var. nov.

Two females, from Bowen, appear to represent another variety; of the vittae on each elytron the outer one is distinct, but rather narrow on the shoulder, and vanishes posteriorly, except for a faint infuscation; the inner one, to the naked eye, is very faint even at the base, and absent elsewhere; nevertheless, in a suitable light, the junction of the two may be traced near the apex. The first joint of antennae is slightly infuscated at the apex, and the eleventh is entirely dark, the intermediate ones have the pale basal portion evenly decreasing in extent. The prothoracic impressions are conspicuous, and the stronger elytral punctures closer together than usual.

OIDES CONTINENTALIS, Weise.

This species has the general appearance of *O. albertisi*, of which perhaps it should be regarded as a variety, but the elytral spots purple (on one specimen greenish, on another somewhat bronzy) instead of black, the prothorax more uneven, and with larger punctures. It appears also to be close to *O. velata*, but differs from the description in having the head not dark at the base, the second and third joints of antennae partly dark, and the apical spots of different shape; on *O. velata* they were described as "twice as wide as long." This is certainly not the case on any of the seven specimens of the present species before me, on which they are either exactly as long as wide, or very slightly longer (4.5 mm., as against 4 mm. on one specimen). Moreover, the markings are not infuscations (as applied in the description), but sharply defined, coloured spots. The spots cover about half the surface, the two first are basal and almost circular, the others are subapical, slightly larger than the basal ones, and less evenly rounded; they are all very narrowly separated from the suture and sides, but to the naked eye appear to form two wide fasciae with sinuous inner edges; from five to seven apical joints of the antennae are black, the others are partly pale, the first sometimes entirely pale. The female differs from the male in being larger and wider posteriorly, abdomen less rigid and not notched at apex, and antennae and legs somewhat shorter.

OIDES BIMACULICOLLIS, sp. nov.

Flavous, part of head, two small round spots on prothorax, part of each antennal joint, and the tarsi black or infuscated; suture and three vittae on each elytron purplish or bronze.

Head with median line fairly deep; punctures inconspicuous. Antennae moderately long, fourth joint twice the length of the second. Prothorax very short, surface uneven; punctures rather small, and unevenly distributed. Elytra beyond middle fully twice the width of prothorax; with fairly dense and rather small, but sharply defined punctures, a double row of punctures near the margin, thence to the margin somewhat rugose. Length, 7-10 mm.

Hab.—Queensland: Cairns (E. Allen, F. P. Dodd and H. Hacker).

There are four dark vittae on each elytron, but only seven altogether, as the wide sutural vitta is common to both; (on *O. tigrina* the suture is pale, so that there are eight elytral vittae); from *O. tigrina* it is also distinguished by the bimaculate pronotum. The only other Australian species described as having the prothorax bimaculate is *O. ovatifemnis*, whose elytra are black, with the suture and margins pale. On one specimen the basal half of the head is rather deeply infuscated, on a second specimen rather feebly so; on the third the base is rather narrowly

infuscated, but there is also a dark line between the eyes; each joint of antennae is conspicuously bicoloured, the black part increasing in extent apically. The total width of the sutural vitta is twice that of each of the others, and it is completely isolated, the second, third and fourth are all conjoined near the apex; the fourth is only about half the length of the others.

OIDES VARIIVITTA, sp. nov.

Flavous, elytra orange-flavous, with a wide black vitta on each, parts of antennae, tarsi, and parts of tibiae black or infuscated.

Head with a narrow median line and with a wide transverse one between eyes; punctures inconspicuous. Antennae rather stout, fourth joint slightly longer than the third or fifth. Prothorax almost thrice as wide as long, surface uneven; punctures rather small, and irregularly distributed. Elytra dilated to beyond the middle, where the width is more than twice that of prothorax; surface faintly shagreened and with rather small but sharply defined punctures; margins narrowly upturned. Length, 7.5 - 10mm.

Hab.—Queensland: Coen River (W. D. Dodd and H. Hacker).

The seventeen specimens before me should possibly be regarded as representing a Queensland variety or sub-species of *O. silphomorphoides*; but they differ from the type, and other Northern Territory specimens of that species, in being of a larger average size, elytra more dilated posteriorly and the dark vittae much more variable; more dilated posteriorly, and sometimes commencing beyond the basal third, instead of almost at the base. The vitta on each elytron, of eleven specimens, commences rather narrowly on the shoulder, but at the subhumeral depression it begins to evenly dilate till near the apex it covers half the width of the elytra or even more, its outer edge curves round with the margin, but its inner edge is oblique; on one specimen it is almost divided at the subhumeral impression, on another it is divided, there being a narrow spot on the shoulder and the main portion beginning at the basal third; on four others the humeral portion is absent, the vitta commencing at the basal two-fifths, or even beyond the middle. The female is larger, and more dilated posteriorly than the male, and with shorter antennae.

OIDES POLITA, sp. nov.

Bright castaneo-flavous, muzzle and elytral margins paler, a wide black vitta on each elytron, most of antennae, two apical joints of tarsi, and sides of four basal segments of abdomen black or infuscated.

Head with minute punctures. Antennae rather long and thin. Prothorax fully thrice as wide as long; surface slightly uneven; punctures rather small and unevenly distributed. Elytra beyond the middle more than twice the width of prothorax; punctures

minute, but sharply defined; margins rather widely upturned. Length, 9 mm.

Hab.—Queensland: Cairns (E. Allen).

The type at first glance appears to belong to one of the varieties of *O. vittivaria*, but differs in having the elytra not at all shagreened, and, consequently, they are highly polished instead of sub-opaque; along the middle they are the same shade of colour as the pronotum, the vitta on each wider on the shoulder than elsewhere, the punctures really small, although owing to "waterlogging" appearing larger on the pale parts, the margins conspicuously wider, the prothorax wider, and with shallower depressions (not much reliance is to be placed on this character, however), and the antennae decidedly longer and thinner, the fourth joint being at least half as long again as the third or fifth, and the sides of abdomen dark. The black vitta on each elytron extends almost from base almost to apex, at an even distance from the margin, except at the subhumeral depression, near the base it occupies more than half the width, posteriorly it is somewhat narrowed, but unevenly so on the inner side; four basal joints of the antennae are pale, the five following ones are blackish (the others are missing from the type).

OIDES SEXMACULIPENNIS, sp. nov.

Flavous, parts of antennae, of tibiae, and of tarsi infuscated; elytra with six, rather small, black spots.

Head with median line well defined; punctures inconspicuous. Antennae not very long, fourth joint distinctly longer than third or fifth. Prothorax fully thrice as wide as long; surface slightly uneven; with rather small, irregularly distributed punctures. Elytra widest before the middle, due to marginal expansion; with fairly dense and sharply defined, but rather small punctures. Length, 9–10 mm.

Hab.—Queensland: Coen (H. Hacker, No. 257).

Readily distinguished from other Australian species by the elytral spots; of these four are irregularly rounded, each about the size of an eye, and placed transversely slightly before the middle, the other two are slightly larger, still less regular, and subapical; of the antennal joints the first is entirely pale, the second to fourth are largely pale, the fifth and sixth rather narrowly at the base, and the eleventh at its apex; the infuscation of the legs is but slight. The female differs from the male in being wider, with shorter antennae and legs, and in the apex of abdomen.

OIDES ARITHMETICA, sp. nov.

Bright flavous, head, most of antennae, a 3-shaped mark on elytra, and abdomen black.

Head polished, median line faint, a deep impression between eyes; punctures indistinct except in front. Eyes large and

prominent. Antennae moderately long, fourth joint longer than the adjacent ones. Prothorax about thrice as wide as long; surface slightly uneven, with minute irregularly distributed punctures. Elytra widest almost in exact middle, margins comparatively wide; punctures small and rather sparse. Length, 8 mm.

Hab.—Queensland: Coen River (W. D. Dodd).

Readily distinguished by the conspicuous apical 3 on the elytra, the part on each elytron commences rather narrowly on the suture at about the apical third, is rather dilated at the apex, curves round on the side, from about the middle of which it turns inward to terminate as a rounded knob. In a good light three very thin neurational lines may be seen on each elytron. The front legs of the type are malformed, but the species is such a distinct one that it has been named.

DORYPHOROIDES, gen. nov.

Elytra with sides continued below level of sterna and abdomen, margins narrow; epipleurae deep, fairly wide adjacent to sterna and thin elsewhere. Metasternum large, with a long and rather acute median projection, continued to front of middle coxae. Tibiae unarmed at apex; claws each with a large appendix. Oblong-elliptic, strongly convex. Other characters as in *Oides*.

By Chapuis' table³ this genus should be referred to the first group, Adoritiens, or the Galerucides, and there⁴ associated with *Cerochroa*, which appears to be the only other known genus of the subfamily, with the metasternum armed, but which has the antennae clavate. The armature is somewhat as in several species of *Doryphora*. Type of genus *D. amplipennis*.

DORYPHOROIDES AMPLIPENNIS, sp. nov.

Flavous; basal half of head, some of the mouth parts, scutellum, suture (very narrowly), sterna, abdomen, tibiae, tarsi and apex of femora black or blackish. Upper surface glabrous.

Head small, median line lightly impressed, a fairly deep impression between eyes; punctures inconspicuous. Antennae not very stout, extending to about hind coxae, third joint almost twice the length of second, the length of fifth, and slightly shorter than fourth, eleventh semidouble. Prothorax about thrice as wide as the median length, sides slightly oblique, hind angles obtuse front lines rounded off; surface slightly uneven, and with rather sparse, sharply defined punctures about middle, becoming smaller and denser on sides; base apex and sides finely margined. Scutellum rather large, curvilinearly triangular; with minute punctures. Elytra large, widest at about basal third, where the width is about thrice that of prothorax; punctures

3. Chapuis, Lacord. Gen. Col., xi, p. 154.

4. L.c., p. 156.

rather small, but sharply defined, and numerous but not crowded. Legs not very long. Length, 11–12 mm.

Hab.—Queensland: South Johnstone River (H. W. Brown).

The general appearance of this species is like that of *Macrolelodes crassus* (of the Dascillidae), on a greatly enlarged scale. On close examination very fine striae may be seen traversing every part of the metasternum, of both this and the following species, although comparatively few may be seen at the same time.

DORYPHOROIDES BICOLOR, sp. nov.

Bright flavous; antennae, except basal joint and part of the second, and most of elytra black.

Head small, median line narrow and well-defined, a fairly deep impression between eyes; punctures small, some parts obliquely strigose. Antennae extending almost to third segment of abdomen. Prothorax about thrice as wide as the median length, sides gently rounded; punctures not very large, but sharply defined, becoming denser and smaller on sides; base apex and sides finely margined. Scutellum almost impunctate. Elytra wide and strongly convex; with sharply defined but not very large or crowded punctures; margins moderately wide and upturned. Length, 12 mm.

Hab.—New Guinea: Manumbo.

About the size of the preceding species, but differently coloured, with longer antennae, elytra with somewhat wider margins and more conspicuous, although not very large, punctures. The pale portion of the elytra is basal and shorter than the prothorax, except on the sides, where it is subtriangularly continued to about one-third from the base.

ART. II.—A Revision of the Cainozoic Species of *Glycymeris* in Southern Australia.

By F. CHAPMAN, A.L.S., and F. A. SINGLETON, M.Sc.

(With Plates I.-IV.)

[Read 13th March, 1924.]

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Introduction.

In the course of a revision of the fossil fauna of Ryansford, of Lower Tertiary age, a problem has arisen regarding the nomenclature of a species of *Glycymeris*. It has seemed desirable, therefore, to consider the Cainozoic forms in some detail, and to attempt to indicate the specific limits and relationships of one of the most variable of our molluscan genera, the modifications of which may be largely due to conditions of environment, as well as to factors of zonal position.

The material here dealt with includes the glycymerids of the collections of the National Museum, Melbourne (including the Dennant coll.); the private collections of Mr. F. A. Cudmore (including part of the T. S. Hall coll.), Mr. W. J. Kimber, and of the authors; in addition to type material from the Tate Museum, Adelaide University, and the Tasmanian Museum, Hobart, together with numerous specimens from various collectors, which are duly recorded in the text. In all, probably not less than two thousand specimens have been examined, a series which has enabled us to deal with the specific limits in a more satisfactory manner than would otherwise have been possible.

In more than one instance forms previously recorded under a single specific name have been split up into two or more species. In such cases it has been deemed prudent to record only those localities from which we have seen specimens, although in the majority of cases the correct specific name may be hazarded with a high degree of probability.

In the systematic section of the paper the species are dealt with primarily in stratigraphic sequence; secondarily in order of original description. In the table of specific characters, however, the species are arranged in approximate order of similitude, in order that differential features may be more readily recognised. The table of stratigraphic ranges of species indicates their approximate relations in time as well as in respect to each horizon, but is not to be taken as necessarily indicating phylogenetic sequence, for which our present state of knowledge is regarded as insufficient.

The paucity of post-Tertiary examples of the genus is noteworthy in such collections as were available to us, but further collecting will doubtless fill in the gaps.

Except for the tentative use of two of the groups suggested by Marwick¹ for the Neozelanic Tertiary species of the genus, no attempt has been made to utilise subgenera, since we understand that Mr. H. J. Finlay, of Dunedin, will shortly publish a communication on the subject. Indeed, although our species may be conveniently allotted to the "*Axinea*" and "*laticostata*" groups of Dr. Marwick, we are doubtful, in view of the occurrence of annectant forms, of their possible subgeneric value. It is noteworthy that there appear to be no Australian representatives of Marwick's third, or "*huttoni*" group, despite its relatively great antiquity in the New Zealand region, where it makes its first appearance in Cretaceous times. We have also refrained, except in one instance, from instituting comparisons between Australian and New Zealand shells, since in many cases affinities are with forms to be described by Finlay in his paper, which we have been allowed to read in manuscript, and the relations of the two faunas are therefore left for him to deal with.

1.—Trans. N.Z. Inst., Vol. LIV., 1923 p. 64.

Systematic Description.

Genus *Glycymeris*, Da Costa, 1778.

GLYCYMERIS CAINOZOICA, T. Woods sp.

(Pl. I., Figs. 1a, 1b, 2a, 2b, 3, 4; Pl. IV., Figs. 1, 2, 3.)

Cucullaea cainozoica, T. Woods, 1877, Pap. Roy. Soc. Tas. for 1876, p. 111.

Pectunculus cainozoicus, T. Woods sp., Tate, 1886, Trans. Roy. Soc. S. Austr., Vol. VIII., pp. 136, 137, Pl. X., Figs. 8a,b. Johnston, 1888, Geol. Tas., Pl. XXXI., Figs. 13, 13a,b. Harris, 1897, Cat. Tert. Moll. Brit. Mus., Pt. I., Australasia, p. 340.

Description by T. Woods, 1877.—“Shell roundly trigonal, oblique, globose, smooth, faintly and closely marked with radiating ribs and concentric striæ, the latter well defined and somewhat rugose at the margin and sides, umbones very acute and recurved; ligamental area, arched, broad, with six straight grooves on each, which are well defined and overlap each other alternately under the umbo, hinge teeth, 6-7, bent under the hinge and then bicuspidate, muscular impressions lanceolate, well defined, the anterior adductor with a slightly lamellar edge, margin finely pectinated with very distinct crenulations which continue in young shells all round as far as the hinge. Young shells are also more quadrate and have the angular ears slightly developed. Altogether the shell is intermediate between *Cucullœa* (*sic*) and *Pectunculus* and partakes somewhat of the character of both genera.”

Additional Note on T. Woods' Types.—We have been favoured by Mr. Clive E. Lord, Director of the Tasmanian Museum, with an opportunity of examining the type material. This consists of three separate valves, one gerontic and two smaller ephebic examples. The largest specimen, which was indicated by label as the type, agrees in the main with Tenison Woods' description above quoted, and is here regarded as the holotype. The surface ornament is very poorly preserved, and it is evident that Woods' description of it must have been taken from the two smaller but better preserved specimens, which are regarded by us as paratypes. Since the type material has not hitherto been figured, we take the opportunity to figure the holotype and one of the paratypes, and upon them we make the following observations. The sub-acuminate character of the umbonal region is well marked in the holotype, the anterior and posterior angles being steeply truncated, with the longer slope on the posterior. This extreme obliquity appears to be a gerontic character, whilst the sloping shoulders of the holotype are regarded by us as an individual feature and somewhat abnormal in the species. Additional characters seen are the strongly margined rim of the pos-

terior adductor scar, and the distinct, short, rounded sinus. On the cardinal line there are five teeth on the anterior series, and eight on the posterior. The ligamental area shows eight striae in a space of about 2.5 mm.

The shell surface as seen in the paratype figured is marked with fine radii crossing the slightly lamellose growth lines; the radii being in fasciculi of four, separated by a deeper line, thus forming a depressed quadriplicate costa.

Dimensions of Holotype.—Length (ant-post.), 34 mm. Height, 32 mm. Thickness of valve, 11.5 mm.

Observations.—Tate, in 1886 (*loc. supra cit.*), figured as a variety of this species a shell from Muddy Creek, with the comment: "This differs from the type in being more orbicular, less narrowed at the hinge-line—characters very conspicuous in young shells. The variety is hardly separable from *P. pulvinatus*, Lamk., of the Parisian Eocene, which is, however, more gibbous at the umbones, and is equilateral.

Dimensions.—Length, 45; width, 42; thickness through valves, 33 millimetres."

Examples from this locality (Muddy Creek, Lower Beds) show a variation in outline from the orbicular form figured by Tate (*loc. cit.*, Pl. X., Figs. 8a,b.), towards the greater obliquity of the holotype, the sloping shoulders of which we have already indicated as somewhat atypical of the species. This variation may be seen in the series on Tate's original tablet, lent to us from the Adelaide University Geological Department, and we here figure (Pl. I., Figs. 3, 4), in addition to the original of Tate's figure, the adjoining shell as an example of the more oblique form. The dimensions of the shell in the right hand upper corner of the tablet, marked by Tate as the original of his figure, with which it agrees in dimensions and shape, are as follows:—Length (ant-post.), 40 mm.; height, 38 mm.; thickness through valve, 15 mm.; so that a discrepancy exists in respect to the dimensions given by Tate in his description. It may be noted, moreover, that the figure has evidently been reversed in lithographing, since the specimen proves to be a right valve. The corresponding dimensions of the more oblique specimen (right valve), here figured for the first time (Pl. I., Fig. 4), are 46.5 mm., 45 mm., and 16.5 mm.; while those of the largest example known to us from the same locality (in the Dennant collection at the National Museum) are 67 mm.; 60 mm., and 24 mm. respectively, thus exhibiting well the increase of obliquity in the extreme stage of geronticism.

The outline and degree of inflation are thus seen to be inconstant features, and while the Balcombian shells show a tendency towards a planation of the surface ornament, neither character can be regarded as of even subspecific value, and we therefore follow Tate in refraining from the introduction of a varietal name.

Harris (*loc. cit.*) gives a brief description of the species, of which he remarks: "It is closely allied to *P. cor*, Lamarck, and young specimens of that are separated with difficulty from the present species. *P. Cainozoicus*, however, has a relatively longer hinge, the umbones are more elevated and acute, and the depression on either side of the adductor scars is characteristic."

This species name was utilised for Kalimnan shells until 1903, when the latter were separated by Pritchard under the name of *G. halli*, under which species the differential characters are given.

It may be here noted that re-examination of the specimen from Mallee Bore No. 4 at 163'-170', recorded as *G. cainozoica*, induces us to refer it to *G. halli*, so that the former species is absent in this series of borings.

G. cainozoica appears to be the earliest representative in the Australian Cainozoic succession of the division of the genus recently recognised in the New Zealand Tertiaries by Marwick² as the "Axinea group."

Occurrence.—Balcombian (Oligocene): Clifton Bank, Muddy Creek, Victoria (Tate, Dennant, Hall and F.A.S. colls.). Also recorded by Hall and Pritchard from Balcombe Bay.

Janjukian (Miocene): Holotype and paratypes from Table Cape, Tasmania, in the Hobart Museum (also Tate, Hall, and Nat. Mus. colls.); Bird Rock Cliffs, Torquay (Tate and F.A.S. colls.); Shelford (Dennant and J. M. Wilson colls.); Rutledge's, near Geelong (T. S. Hall coll.), Victoria. Adelaide Bore (Tate coll.); Murray River, four miles below Morgan (F. A. Cudmore coll.), South Australia. Also recorded by Johnston, from Flinders Is., Bass Strait; by Tate and Dennant, from Camperdown, Vic., and Aldinga, lower beds, S.A.; by Hall and Pritchard, from Wilkinson's No. 4 locality, Aire Coast; Fishing Point, Aire River; Waurin Ponds; Batesford; Orphanage Hill, Fyansford; and South Yarra, all in Victoria; by Dennant and Clark, from Moitun Creek, Skinner's and Dreir's, on the Mitchell River, V.; by Dennant and Kitson, from Cape Otway, V., Mount Gambier and Lake Alexandrina, S.A. A record from Maude (H. and P.; T. and D.) is presumably referable to *G. maudensis*, sp. nov.

Kalimnan (Lower Pliocene): Nodule bed between Clifton Bank and MacDonald's. Muddy Creek, derived from older series (coll. and pres. Nat. Mus. by F.C.); also Beaumaris, V., form annectant with *G. halli* (Nat. Mus. coll., pres. J. A. Kershaw; also Dennant coll.). Records from Horsham (D. and K.), and Jimmy's Point (H. and P.) may perhaps be based on *G. halli*.

GLYCYMERIS GUNYOUNGENSIS,³ sp. nov.

(Pl. I., Figs. 5a, 5b, 6; Pl. IV., Fig. 4.)

Pectunculus laticostatus, Quoy and Gaimard, McCoy, 1875, Prod. Pal. Vict., dec. II., pp. 26, 27, Pl. XIX., Figs. 12, 13 (*non* 9, 10, 10a, 11). Tate, 1886, Trans. Roy. Soc. S. Austr., Vol. VIII., p. 137. Harris, 1897, Cat. Tert. Moll. Brit. Mus., Pt. I., Australasia, p. 341.

Pectunculus M'Coyi, Johnston, 1888, Geol. Tas., Pl. XXXI., Figs. 1c, 1d, (*non* 1, 1a, 1b); (*non* Johnston, 1885).

Glycymeris maccoyi, Johnston sp., Chapman and Gabriel, 1914, Proc. Roy. Soc. Vict., Vol. XXVI. (N.S.), Pt. II., pp. 303, 304, Pl. XXIV., Fig. 1 (*non* 2-5). Chapman, 1916, Rec. Geol. Surv. Vict., Vol. III., Pt. IV., Pl. LXVII., Fig. 1 (*non* 2-5).

Description of Holotype.—Right valve of an ephebic example; sub-circular, rather depressed; hinge-line moderately short; the dorsal margin at the anterior and posterior ends truncately rounded to meet the more evenly curved ventral margin. In profile the shell is only moderately inflated in the umbonal region, and is more depressed towards the ventral portion. The ornament consists of 33 regularly radiating riblets, somewhat angulate in the neanic stage, becoming more rounded in the ephebic, and depressed and less distinct in the gerontic stage; the interspaces are well-marked but narrow. The shell surface is marked by distinct concentric undulatory lines of growth, which in the ephebic stage become more laminate or squamose. Growth stages not very distinctly defined, in contrast to some other Victorian species, such as *G. coniera* and *G. ornithopetra*. Umbo inconspicuous, slightly opisthogyrate. Hinge-teeth of medium strength, arcuately disposed; about 10 in anterior and 11 in posterior series; individually short and very slightly uncinat. Striated area of limited dimensions, depth slightly under 1 mm. in the holotype, in which space there are about 4 striae. Anterior muscle scar elongate-rhomboidal; posterior scar sub-trapezoidal, and bounded in front by a thin ridge. Inner ventral margin of valve narrow, more or less flat, with 21 inwardly excavated denticles, the points of which coincide with the interradianal grooves of the outer surface, and are the terminations of very faint radial markings on the interior of the shell which are visible only in oblique light.

Dimensions of Holotype. — Length (ant-post.), 22.5 mm. Height, 21.5 mm. Thickness of valve, 5 mm.

Description of Gerontic Form (Paratype).—This shell, a right valve, shows in the ephebic stage an angulation of the radial costation which is entirely lost in the gerontic stage, the ribs becoming uniformly rounded and even depressed. At the same time the concentric laminar growth-lines, which are more strongly

3.—From Gunyoung, a former name of Grace's Creek.

developed in the earlier stages in the intercostal spaces, are in this latest stage strongly developed over the whole surface as a tegulate frilling.

Dimensions of Paratype.—Length (ant.-post.), 30 mm. Height, 28 mm. Thickness of valve, 7 mm.

Observations.—The earliest reference to the present form was made by McCoy in 1875 (*loc. supra cit.*), when he figured an example (Pl. XIX., Figs. 12, 13) without citing a locality. This specimen is contained in the National Museum collections (Reg. No. 12382), and we are enabled to give the habitat as Balcombe Bay ("Schnapper Point"). It is a right valve in the neanic stage, and as such presents a more circular outline and less prominent umbo than in the ephebic stage. As is the case with many of the figures given in the Prodrusus, the figures on this plate have been reversed in lithographing.

Tate⁴ has tentatively included under *P. McCoyii*, Johnston, a Muddy Creek shell which we now refer to the above species. This he describes as "A thin, sub-orbicular, narrowed at the hinge, depressed shell, never exceeding 30 millimetres diameter." In regard to specimens from this locality (Muddy Creek, Lower Beds), we note that they agree in all essential particulars with the examples from the Port Phillip localities of Grice's Creek and Balcombe Bay.

Chapman and Gabriel (*loc. supra cit.*), in discussing the specimens figured by McCoy in the Prodrusus, regarded them as divisible into two mutations of a species referred by them to *Glycimeris maccoyi*, Johnston sp., as follows:—

Form *a*.—A small shell from Grice's Creek. Also larger valves from Corio Bay.

Form *b*.—A large and ponderous shell from Bird Rock.

We now refer the Grice's Creek shell to *G. gunyoungensis*, and describe the Bird Rock form as another new species under the name of *G. ornithopetra*. In regard to the specimens stated by Chapman and Gabriel to be from Corio Bay, we regard them as belonging, not to the Grice's Creek form, but to the Bird Rock (Torquay) species, *G. ornithopetra*. An emendation also becomes necessary as regards the localities of McCoy's figured specimens, as given by Chapman and Gabriel. The small Balcombian example comes, not from Grice's Creek, but from Balcombe Bay, about five miles to the south-south-west. The medium sized shells were stated to be from Corio Bay, on the authority of an old label of the Geological Survey of Victoria. No shells from that locality, comparable with these examples, either in size or other characters, are known to the present authors, whilst the specimens can be exactly matched from Bird Rock Cliffs, and it is suggested that they, in common with the largest specimen figured by McCoy, came from the latter locality. Further confirmation of this view is obtained from the matrix preserved in one

of the shells, which is comparable in character with a bed near the Glycymeris band at Bird Rock Cliffs, but is distinct lithologically from anything known at Corio Bay. It is known that many of the old Survey collections from the Geelong district were not localised, and this will account for the error in confusing the Torquay with the Corio Bay collections.

The results of our examination of the specimens figured (without localities) by McCoy on Plate XIX. of the *Prodromus*, are here tabulated:—

Fig. 14 (9 in error on plate). Reg. No. 12385.⁵ Left⁶ valve. G.S.V. locality Ad 23—Bird Rock Bluff, Torquay, near Geelong. (= *G. ornithopetra*.)

Figs. 10, 11. Reg. Nos. 12383-4. Right and left valves. ? Bird Rock Bluff. (= *G. ornithopetra*.)

Figs. 12, 13. Reg. No. 12382. Right valve. Balcombe Bay, Port Phillip. (= *G. gunyoungensis*.)

It will thus be seen that examples of the present species (*G. gunyoungensis*) have hitherto been recorded as *Pectunculus latirostratus*, Q. and G., and, later, on rejection of the New Zealand species from the Australian fauna, as *G. maccoyi*, Johnston sp. We show subsequently, in dealing with Johnston's species, that this form is restricted to the type locality at Table Cape, Tasmania, and Ooldea, South Australia. Compared with similar-sized specimens of *G. maccoyi*, our species differs in outline, especially in the subtruncation of the hinge-line, and in its very much smaller dimensions in the adult form.

While the majority of the Bird Rock or Spring Creek specimens, hitherto recorded as *G. maccoyi*, Johnston sp., are here regarded as a new species, *G. ornithopetra*, we may note that they are accompanied by occasional diminutive examples of *G. gunyoungensis*, which at this locality and elsewhere has persisted to a later horizon. They may readily be separated from juvenile examples of *G. ornithopetra* by the fewer number of ribs and by the truncation of the dorsal margin, a character which is absent in the neanic stage of the latter species.

Although we include the form of *Glycymeris* found at Orphanage Hill, Fyansford, with the typical *G. gunyoungensis* of Grice's Creek, at the same time we recognise that here (at Fyansford) the valves have a decided tendency to vary in the direction of *G. subtrigonalis*, Tate sp., in regard to the angularity of the cardinal arch, but differ from typical specimens of *G. subtrigonalis* from the River Murray Cliffs in having a thinner shell, as is the case with typical *G. gunyoungensis*. The ancestral characters are so slightly established, however, as to preclude the necessity of even a varietal distinction.

It is evident that *G. subtrigonalis* is the closest ally of the species under consideration, *G. gunyoungensis*. From actual com-

5.—Numbers refer to the Register of the National Museum, Melbourne.

6.—Figures have been reversed in lithographing.

parison of the holotypes of the two species, we note that the latter differs from Tate's species in its thinner and depressed shell with rounded rather than subangulate outline, its gently arcuate and narrow hinge area, and in its more numerous ribs.

An examination of the examples of *Glycymeris* in the Dennant collection of Limestone Creek fossils, tentatively referred by him to *G. (?) subtrigonalis*, has led us to refer them to *G. gun-youngensis*, with typical Balcombian examples of which they agree in character of ornament, differing only in their smaller size and greater inflation of the valves. They appear, therefore, to be micro-morphic forms of that species, which have reached the gerontic stage before attaining their usual dimensions, as shown by the close concentric ornament and crowding of the growth stages. A recent discovery by one of us (F.A.S.) of fossiliferous Lower Tertiary clays on the Glenelg River, near the junction of Limestone Creek, affords an explanation of the apparent occurrence of this species on so high a horizon as the Werrikooian. We have no doubt that the shells under consideration were derived from these lower beds, with the fauna of which they agree in state of preservation, and it is probable that several of Dennant's records of Lower Tertiary species in the Werrikooian deposits are due to admixture from this source.

Occurrence.—Balcombian (Oligocene): holotype and paratype from Grice's Creek, Frankston, coll. W. Kershaw, in Nat. Mus. (also Cudmore and F.A.S. colls.); Balcombe Bay (Nat. Mus., Cudmore and F.A.S. colls.); Altona Coal Shaft (coll. F.C., in Nat. Mus.); Muddy Creek, lower beds (T. S. Hall, F.A.S., and Nat. Mus. colls.).

Janjukian (Miocene): Bird Rock Cliffs, Torquay (F.C. and F.A.S. colls.); Point Campbell (T. S. Hall coll.); Curlew (coll. Rev. E. H. Chapple, in Nat. Mus.; also Dennant and F.C. colls.); Corio Bay (F.C. coll.); Orphanage Hill (G.S.V. coll. in Nat. Mus.; also Hall and F.A.S. colls.) and Griffin's, near Fyansford (T.S.H.); Native Hut Creek and Inverleigh (T.S.H.); Murgheboluc (var. annectant with *G. subtrigonalis*, in T. S. Hall coll.); Cape Otway and Gellibrand River (Dennant coll.); Mitchell River at Dreir's (F. A. Cudmore coll.), and Skinner's (Hall and Cudmore colls.); Neumerella, near Orbost (cast, coll. F.C. in Nat. Mus.), all in Victoria. Adelaide Bore, South Australia (on Tate's type tablet of *G. lenticularis*).

Janjukian (?): Glenelg River, near Limestone Creek (Dennant coll. Nat. Mus.).

Many records of *G. maccoyi* or *G. laticostata*, from Janjukian localities, are probably referable to the present species, but cannot be allocated in the absence of specimens.

GLYCYMERIS MACCOYI, Johnston sp.

(Pl. I., Figs. 7a, 7b; Pl. IV., Fig. 5.)

Pectunculus McCoyi, Johnston, 1880, Pap. Roy. Soc. Tas. for 1879, p. 41.

Pectunculus M'Coyi, Johnston, 1885, Pap. Roy. Soc. Tas. for 1884, pp. 199, 200.

Pectunculus McCoyi, Johnston, Tate, 1886, Trans. Roy. Soc. S. Austr., Vol. VIII., p. 137.

Pectunculus laticostatus, Quoy and Gaimard, Harris, 1897, Cat. Tert. Moll. Brit. Mus., Pt. I., Australasia, p. 341.

Glycymeris maccoyi, Johnston sp., Chapman and Gabriel, 1914, Proc. Roy. Soc. Vict., Vol. XXVI. (N.S.), Pt. II., p. 303, Pl. XXIV., Fig. 4 (*non* 1-3, 5). Chapman, 1916, Rec. Geol. Surv. Vict., Vol. III., Pt. IV., Pl. LXVII., Fig. 4 (*non* 1-3, 5).

Description by Johnston, 1885: "Shell orbicular, convex, slightly broader than long, somewhat flattened towards beak, sub-trigonal when young. Surface with 29 to 31 regular radiating convex ribs separated by somewhat narrower interspaces; ribs broadening and becoming less convex towards the margin; marginal extremities rarely obsolete in old specimens; whole surface finely shaply (*sic*) striated concentrically; hinge teeth, generally 10 on each side the three nearest beak smaller and frequently obsolete on one or both sides in old specimens; inside of margin sharply denticulated; ligamental area depressedly triangular with close V shaped striae—in young specimens, 6-7—in specimens of about $2\frac{1}{2}$ inches long, 8-9, the anterior side of beak having generally one stria more than the posterior side.

Mature specimens $2\frac{1}{2}$ to 3 inches long. This shell, hitherto, has erroneously been referred to *P. laticostatus*, Quoy."

Description of Neotype.—Left valve of a gerontic form. Large, stoutly built, moderately convex. Outline in neanic and ephebic stages subcircular, becoming slightly subangulate on the ventral border in the gerontic stage. Hinge-line fairly long; anterior margin rounded, posterior subangularly so. Surface ornamented with 30 rounded ribs, which become flattened in the ephebic and obsolete in the gerontic stage. The ribs are crossed by fine undulate concentric laminae, which in the later stages becomes more salient. Beak small, opisthogyrate, not inflated. Ligamental area fairly long and low, with eight striae in a space of 3 mm. Teeth 8 on each side; anterior geniculate, posterior thick and strongly arched. Anterior adductor scar large, reniform; posterior sub-trigonal and ridged on inner margin. Inner ventral margin of shell planate, with 20 denticulae, interradian in position.

Dimensions of Neotype.—Length (ant.-post.), 57 mm. Height, 54.5 mm. Thickness of valve, 15 mm.

Historical Account.—The identification of this species has occasioned us considerable trouble, and it will be seen that we now

restrict the name to a form which is abundant, so far as is at present known, only at one locality, Table Cape, Tasmania, although occurring also at Ooldea, South Australia. It is convenient to outline at this point the history of Johnston's species name.

In 1880 Johnston remarked that in the Table Cape form there were invariably 29 radial ribs, as against 39 ribs shown in McCoy's *Prodromus* figures of a Victorian form identified as *P. laticostatus* by that author (*G. ornithopetra* of the present revision). He goes on to say (*loc. cit.*): "If there is no error in description (in p. 26, Decade II., Geol. Surv. of Vic.), and if the difference is a permanent and specific one, I would propose the name *Pectunculus McCoyi*, for the Table Cape variety. In all other respects it answers Quoy and Gaimard's description." Johnston also states that he has a specimen from Schnapper Point, showing 29 ribs. This locality is identical with Balcombe Bay, the shells from which we refer to *G. gunyoungensis*.

In 1885 Johnston stated that he had compared Recent examples of *P. laticostatus* from New Zealand, with the Table Cape shell, of which he furnished the full description quoted above. He regarded the Recent *P. flabellata*, T. Woods, of the Tasmanian coast, as a closer ally of the Table Cape fossil, and remarked of *P. laticostatus* (*op. cit.*, p. 200): "The latter differs from *P. McCoyi* in being much more solid, and in having invariably 10 more ribs; the length also, generally exceeds the breadth and the convexity towards margin. With *P. flabellata*, Tenison Woods, it differs in being less solid and in having invariably 7 more ribs; *P. flabellata* having invariably 24. The teeth on the latter are generally 10 as in *P. McCoyi*, and in this respect and in ligamental area show a closer correspondence with the latter than with *P. laticostatus*. *P. flabellata*, in Tasmania, moreover, is invariably exactly as broad as it is long. It would appear therefore that the characteristic shell of Table Cape is not identical with living species, and that it seems to be an intermediate form between *P. flabellata*, Tenison Woods, and *P. laticostatus*, Quoy, although showing a closer alliance with the former."

In the same year Tate,⁸ in the course of a critical examination of Table Cape molluscan species alleged to have living representatives, made the following observations under the name of *Pectunculus laticostatus*: "I do not acquiesce in Mr. R. M. Johnston's rejection of the above name for the species so common in the Table Cape deposits, which he names *P. McCoyi*. (Proc. Roy. Soc., Tasmania, for 1879, p. 41.) An allied species is plentiful in the River Murray Cliffs, near Morgan, but it has more resemblance to the Australian species, *P. flabellatus* of Tenison Woods than to the New Zealand *P. laticostatus*."

The Murray River species, to which Tate refers, was afterwards described by him as *P. subtrigonalis*.

8.—Tate, 1885, Pap. Roy. Soc. Tas. for 1884, p. 213.

This view was evidently soon reversed by Tate, for Johnston,⁹ in a paper communicated to the Royal Society of Tasmania at its next meeting, states that Tate concurs with his determination in respect of *P. McCoyi*.

In the following year, 1886, Tate admitted both Quoy and Gaimard's and Johnston's species names, referring to *P. laticostatus* (?) shells from Bird Rock and Schnapper Point, and to *P. McCoyi* the Table Cape shells, as well as examples from Muddy Creek and Schnapper Point (regarded in this revision as *G. gunyoungensis*). An additional locality for Johnston's species, accepted by Tate on the former author's record of the previous year, was Cape Schanck, Victoria. While a fossiliferous Batesfordian (Janjukian) limestone has recently been recorded¹⁰ from near Cape Schanck, this is certainly not the locality referred to by Johnston, and the present authors suggest that that author meant the well-known outcrop at Balcombe Bay, near Mornington, some 20 miles to the north, since the term Cape Schanck Peninsula was used in the early days to embrace the whole of this area.

In our observations on an allied species, *G. ornithopetra*, which accompanies *G. maccoyi* at Table Cape, we show that Johnston's figures in the Geology of Tasmania, 1888, Pl. XXXI., Figs. 1, 1a-d, purporting to represent the latter species, do not do so, but belong to other and distinct forms.

In 1896 Pritchard,¹¹ in the course of a revision of the Table Cape fauna, included *P. maccoyi*, Johnston, in the synonymy of *P. laticostatus*, Q. and G., under which name he placed the Table Cape examples.

In the same year Tate and Dennant¹² remarked: "*Pectunculus laticostatus*, Q. and G., so-called, of the Eocenes of Tasmania and Southern Australia, is, in our judgment, a distinct species, and should be quoted as *P. McCoyi*, Johnston, though the differential characters relied upon by its author are based upon misconception," although earlier in the same paper (*op. cit.*, p. 133) they had recorded, with a query, *Pectunculus laticostatus*, Q. and G., in a list of Table Cape fossils, quoting *P. McCoyi*, Johnston, as a synonym.

Harris, in 1897, utilised Quoy and Gaimard's name, and stated (*loc. cit.*): "Comparison of authenticated specimens of *P. maccoyi*, Johnston, with the living *P. laticostatus*, enables the writer to state, definitely, that they are synonymous." Judging from the localities given by Harris, that author has included at least two other Australian Tertiary species under the name of the New Zealand form.

We refer to *G. maccoyi*, Johnston sp., the Table Cape shell figured under that name by Chapman and Gabriel in 1914 (*op.*

9.—*Op. cit.*, p. 220.

10.—Chapman, 1914, *Rec. Geol. Surv. Vict.*, Vol. III., Pt. III., pp. 318, 319.

11.—*Proc. Roy. Soc. Vict.*, Vol. VIII. (N.S.), pp. 130, 131.

12.—*Trans. Roy. Soc. S. Austr.*, Vol. XX., Pt. I., p. 147.

cit., Pl. XXIV., Fig. 4), and reprinted by the former in 1916 (*op. cit.*, Pl. LXVII., Fig. 4), and these figures (of the same shell) are the only ones referable to Johnston's species, as here defined, hitherto published.

Chapman and Gabriel also stated that a similar, but smaller, form occurred at Mornington, Muddy Creek (lower beds), and Corio Bay, but specimens from these localities are here referred to *G. gunyoungensis*. They further remark (*op. cit.*, p. 304) that typical *G. maccoyi* at Table Cape is accompanied by shells comparable with the Bird Rock form figured by McCoy as *P. laticostatus*, Q. and G., and referred by them to *G. maccoyi*, mutation *b* (*G. ornithopetra* of the present revision).

Finally, in 1919, W. L. May¹³ listed *G. laticostatus*, Q. and G., in a census of the Table Cape mollusca, but in a personal communication to one of us (F.C.)¹⁴ he has withdrawn the identification.

Observations.—Study of a series of Table Cape specimens collected by Mr. F. A. Cudmore has shown that examples agreeing with R. M. Johnston's original description are separable from the more numerous costated form herein described as *G. ornithopetra*, under which latter species the differential characters are given. An examination of the type of Johnston's species was, therefore, desirable, and application was made for it to Mr. Clive Lord, Director of the Tasmanian Museum, Hobart, which contains the collections of the late R. M. Johnston. A search by Messrs. Lord and May proved unsuccessful, and it is probable that no primary type was designated by Johnston. We have therefore selected as neotype of *Glycymeris maccoyi*, Johnston sp., a gerontic example collected by Mr. F. A. Cudmore, from the same locality and horizon ("Crassatella Bed"), as Johnston's specimens, and give a description of it above.

In some diminutive shells from this locality the number of ribs is not more than 17-21, while the outline tends towards the sub-trigonal. After comparison with Torquay examples referred by us to *G. gunyoungensis*, we have decided to refer these Table Cape shells to the juvenile stage of *G. maccoyi*. This species, together with the allied *G. ornithopetra*, appears at this locality to have been in a somewhat unstable condition as to outline and also degree of inflation, since inflated *G. maccoyi* and depressed *G. ornithopetra* are occasionally met with. These variants, however, group themselves around two types, to which we apply the above names. After careful consideration it does not appear desirable to split the forms still further, on the one hand, nor, on the other, to regard the Bird Rock type (*G. ornithopetra*) as merely a variant of Johnston's species.

Occurrence.—Janjukian (Miocene): neotype (coll. F. A. Cudmore and pres. to Nat. Mus.), and other examples from lower bed at Table Cape, Tasmania (Cudmore, Hall and Nat. Mus.

¹³—Pap. Roy. Soc. Tas. for 1918, 1919, p. 103.

¹⁴—In *litteris*, March, 1924.

colls.); upper beds at same locality (Cudmore coll.). Ooldea, South Australia (mould, Nat. Mus. coll., pres. F. A. Cudmore).

Many records under this name are doubtless referable to other species; those from the Kalimnan being either *G. convexa* or *G. planiuscula*.

GLYCYMERIS LENTICULARIS, Tate sp.

(Pl. I., Figs. 8*a*, 8*b*; Pl. IV., Fig. 6.)

Pectunculus lenticularis, Tate, 1886, Trans. Roy. Soc. S. Austr., Vol. VIII., p. 138, Pl. XI., Fig. 1.

Description by Tate, 1886: "Shell rather thin, orbicular, but slightly transverse, depressed, equilateral; radiately ribbed. Ribs numerous (more than 40), very fine, rounded, narrower than, or about as wide as, the interspaces, crossed all over with fine concentric wavy lines. Inner margin of valves narrowly toothed; umbones very small, approximate; ligamental area very small, cardinal teeth 11 on each side.

Dimensions.—Length, 31; width, 29; greatest thickness through both valves, at about one-third of the distance from the front, 12 millimetres."

Note on Tate's Metatypes.—The original tablet, which has been lent to us from the Adelaide University Museum, shows a series of eleven examples, of which the two uppermost specimens (a pair), although not marked as types, undoubtedly formed the basis of Tate's description. Since the figures of the other species of *Glycymeris* in Tate's paper were reversed by the artist, we suspect that the figure given, which represents a left valve, was taken from the right valve on the left hand upper corner of the tablet, with which the figure otherwise agrees.

The two largest examples (Pl. I., Figs. 8*a*, 8*b*) are right and left valves, respectively, of a single pair, which are here regarded as cotypes, since in his original diagnosis Tate refers to "valves" and gives their united thickness. The coarser ribbing and post-dorsal subtruncation of the hinge line in certain of the specimens induces us to refer them to *G. gunyoungensis*, and in these particular examples, moreover, the number of ribs falls well below the minimum of 40 given by Tate. Our interpretation of the series on Tate's original tablet is set out as follows, taking the specimens in each row from left to right:—

Top Row.

G. lenticularis. Right valve of gerontic example, with 50 ribs. Cotype and probably Tate's figured specimen.

G. lenticularis. Left valve of gerontic example, with 50 ribs. Cotype and opposite valve to above.

MIDDLE ROW.

- G. gunyoungensis*. Right valve of ephebic example, with 34 ribs.
G. lenticularis. Right valve (internal aspect) of ephebic example, with about 44 ribs.
G. lenticularis. Right (?) valve of ephebic example, having post-dorsal margin imperfect, with 42 ribs.

BOTTOM ROW.

- G. lenticularis*. Left (?) valve of ephebic example, with 44 ribs.
G. gunyoungensis. Neanic examples, with 29, 28, 22 and 26 ribs respectively.
G. lenticularis. Neanic example, with 42 ribs.

Observations.—The depressed character of the present form is shared by the later species, *G. planiuscula*, from which it can be at once distinguished by its shorter hinge-line and greater number of ribs. From immature examples of *G. ornithopetra*, which species attains a much greater size in the adult stage, it differs in being more depressed, with greater proportionate length, more numerous ribs, less sulcated interspaces, and shorter hinge-line.

The closest ally of *G. lenticularis*, however, is probably *G. gunyoungensis*, a species to which we have above referred certain of the series of specimens on Tate's original tablet of *G. lenticularis*. The present species may be distinguished by its longer hinge-line and more rounded dorsal margin, and its more numerous and smoother ribs, which are less tegulate or scaly than in *G. gunyoungensis*.

Occurrence.—Janjukian (Miocene): Two cotypes and other specimens from the Adelaide Bore, South Australia, in the Tate coll., Adelaide University Geological Department; also lower beds at Aldinga (W. J. Kimber coll.), in the same State.

GLYCYMERIS ORNITHOPETRA, sp. nov.

(Pl. II., Figs. 9a, 9b; Pl. IV., Fig. 7.)

Pectunculus laticostatus, Quoy and Gaimard, McCoy, 1875, Prod. Pal. Vict. dec. II., pp. 26, 27, Pl. XIX., Figs. 10, 10a, 11, 14 (9 in error on plate), (non 12, 13). Tate, 1886, Trans. Roy. Soc. S. Austr., Vol. VIII., p. 137.

Pectunculus M'Coyi, Johnston, 1888, Geol. Tas., Pl. XXXI., Figs. 1, 1a, 1b (non 1c, 1d); (non Johnston, 1885).

Glycymeris maccoyi, Johnston sp., Chapman and Gabriel, 1914, Proc. Roy. Soc. Vict., Vol. XXVI. (N.S.), Pt. II., pp. 303, 304, Pl. XXIV., Figs. 2, 3 (non 1, 4, 5). Chapman, 1916, Rec. Geol. Surv. Vict., Vol. III., Pt. IV., Pl. LXVII., Figs. 2, 3 (non 1, 4, 5).

Description of Holotype.—The internal aspect of this has already been figured by Chapman and Gabriel, 1914, Pl. XXIV., Fig. 3, and by the former, 1916, Pl. LXVII., Fig. 3.

Right valve; large, strongly convex and deep at the umbo, stoutly built; outline in the neanic and ephebic stages sub-circular, slightly longer than high; in the present gerontic stage it becomes irregularly sub-ovate, with the major diameter dorso-ventral, but somewhat obliquely inclined towards the rear, the ventral border tending to become subangulated at the end of this major axis; anterior margin gently rounded; posterior margin in the gerontic stage definitely angulated where the truncated post-dorsal line meets the ventral border; this angulation increases with age. Surface radially ornamented with 40 subangular to rounded ribs, stronger and thicker on the anterior than on the posterior, and curving slightly posteriorly; ribs in neanic stage more angular than in the ephebic, becoming obsolescent in the gerontic stage. Interspaces between ribs well defined in the pre-gerontic stages, and relatively one-third the space of a rib. Growth-lines very fine, extending above the surface, interradially, as squamose laminae. Growth stages well marked by deeper lines of growth, which cross the entire surface as undulate laminae; 18 in the holotype. Beak opisthogyrate, comparatively small. Hinge-teeth strong, largely encroached upon by area, leaving about 8 teeth on each side; anterior series elongate and uncinat, posterior series strongly arched. Ligamental area short and high; finely striate, in the present example with 10 striae in a space of 4.4 mm. Anterior adductor scar subtrigonal; posterior obovate, ridged on anterior margin. Inner ventral margin subplanate, with about 28 elevated denticulae corresponding to the external interradiial spaces, distinct ventrally, but becoming obsolete towards anterior and posterior.

Dimensions of Holotype.—Length (ant.-post.), 55 mm. Height, 57.5 mm. Thickness of valve, 19.5 mm.

Observations.—This Bird Rock (Torquay) species is clearly an ancestral form related to *G. laticostata*, Q. and G. sp., a Pliocene (Wanganuian) and Recent species in New Zealand, from which it differs, as already pointed out by Chapman and Gabriel (*loc. supra cit.*), in its longer shell and more finely striated ligamental area. In this last character it resembles *G. chambersi*, Marshall,¹⁵ of the Tertiary of Campbell Island, the type material of which species we have been enabled to examine through the good offices of Mr. H. J. Finlay and Professor W. N. Benson. From this species the Australian form differs in its more numerous ribs (40 as against 34 in the respective type specimens), deeper valve, less numerous growth stages (in the neanic stages of both, 3 as against 12), and narrower ligamental area.

15.—*Glycymeris chambersi*, Marshall, 1909, Subantarctic Islands of New Zealand, Vol. II., p. 701. *Glycymeris chambersi*, Marshall, Marwick, 1923, Trans. N.Z. Inst., Vol. LIV., p. 67, Pl. I., Fig. 7.

Hitherto it has been confused with *G. maccoyi*, Johnston, from the Janjukian of Table Cape, Tasmania, from which we note the following points of difference. In *G. ornithopetra* the valves are deeper and the hinge-line shorter, while the ventral border is sub-angularly rounded in the gerontic stage, whereas in *G. maccoyi* it is more evenly rounded. The ribs are more numerous in *G. ornithopetra*, averaging 39 to 40 against 29 to 31 in Johnston's species, and the interspaces are narrower.

Occurrence.—Janjukian (Miocene): abundant at Bird Rock Cliffs, Torquay (=Spring Creek beds), holotype coll. by R. Daintree, in Geol. Surv. Vict. coll., Nat. Mus. (also Cudmore, Hall, F.C., and F.A.S. colls.); Waurin Ponds (Nat. Mus. coll., "pres. J. McKenna," ex. Mortlake Mus.), Victoria. Aldinga, lower beds (W. J. Kimber coll.); Point Turton, Yorke's Peninsula (moulds, F.A.S. coll.); Ooldea (mould, Nat. Mus. coll., pres. F. A. Cudmore), South Australia. Table Cape, Tasmania, upper and lower beds (F. A. Cudmore coll.).

GLYCYMERIS SUBTRIGONALIS, Tate sp.

(Pl. II., Figs. 10, 11, 12; Pl. IV., Fig. 8.)

Pectunculus subtrigonalis, Tate, 1886, Trans. Roy. Soc. S. Austr., Vol. VIII., p. 137, Pl. XI., Figs. *oa, b*. Harris, 1897, Cat. Tert. Moll. Brit. Mus., Pt. I., Australasia, pp. 340, 341.

Description by Tate, 1886: "Shell solid, somewhat sub-trigonal, sub-equilateral, oblique, slightly produced posteriorly, moderately convex, radiately ribbed; ribs about 29, rounded, separated by flat narrower interspaces, the whole surface crossed by regular, sub-distant, subimbricating lamellæ and a few folds of growth; umbones small, approximate; hinge line very short, ligamental area small; cardinal teeth eight in front and seven behind the edentulous centre; internal margin of valves strongly crenate.

This species is conspicuous by its narrow hinge line, the valves attaining the greatest transverse diameter at about four-sevenths the distance from the umbo to the front.

Dimensions.—Length, 32; width, 31; thickness through both valves, 19 millimetres."

Note on Tate's Metatypes.—The tablet of specimens selected by Tate, and lent to us from the Adelaide University Museum, comprises 12 examples, of which the second from the right in the top row, is marked by Tate as the figured specimen. This shell, regarded by us as the holotype, represents the rather oblique shell of the gerontic stage. We here re-figure this and the adjoining specimen on the left, which is a more average example, and is less markedly angular on the dorsal margin. The subtrigonal character of outline seems to make its appearance after the neanic stage, and becomes accentuated in the gerontic. Here again a discrepancy occurs in respect to dimensions. Those of Tate's

figured specimen (holotype) are:—Length, (ant.-post.), 30 mm.; height, 29 mm.; thickness through valve, 8 mm.; with which Chidley's figures agree well. The corresponding dimensions of the shell to the left, figured by us, are 27 mm., 25.5 mm., and 7.5 mm.; while that on the opposite side measures 32 mm. (damaged) by 31.5 mm. by 10 mm., and may possibly be the one measured by Tate. All three shells are left valves, Tate's figures by Chidley having been reversed.

Observations.—The alliance of *G. subtrigonalis* with *G. gunyoungensis* is perhaps the nearest of any of the species dealt with, and separation of juvenile forms is difficult. Differential characters of these two species in the adult form are dealt with in the remarks upon *G. gunyoungensis*.

The specimens recorded under this name from the Kalimnan of Muddy Creek are later described as *G. decurrens*, while a doubtful record from the Werrikooian of the Glenelg River has already been shown to be referable to *G. gunyoungensis* and to belong to an earlier horizon.

We illustrate the internal aspect from a topotype (right valve) collected by F. A. Cudmore, and presented by him to the National Museum. The dimensions of this shell are: Length, 29.5 mm.; height, 28.5 mm.; thickness, 9 mm.

Occurrence.—Janjukian (Miocene): abundant on Murray River, four miles below Morgan, South Australia, holotype in Tate Mus., Adelaide University (also Cudmore and Dennant colls., and Nat. Mus., pres. F. A. Cudmore). Also form annectant with *G. gunyoungensis* from Shelford (Dennant coll.), and Meredith (cf. *subtrigonalis*, Nat. Mus. coll., pres. J. A. Kershaw).

Kalimnan records of this species are probably referable to *G. decurrens*, sp. nov.

GLYCYMERIS MAUDENSIS, sp. nov.

(Pl. II., Figs. 13a, 13b; Pl. IV., Fig. 9.)

Description of Holotype.—Left valve of an epehebic example, differing from similar sized specimens of its near relative, *G. cainozoica*, in the incrassate shell and more subtrigonal outline. Umbonal region prominent, subacuminate, and not strongly incurved as in *G. cainozoica*; umbonal shoulders sloping, with the posterior steeper than the anterior. Ribs depressed, about 28 in number, with intercostal linear sulci; costation conspicuous over larger portion of valve, but becoming obliterated by concentric growth frills in senescent stage. Cardinal area more massive than in *G. cainozoica*, with about 8 teeth on each side; denticulation of ventral edge of valve correspondingly thick.

Dimensions of Holotype.—Length (ant.-post.), 29 mm.; height, 28 mm.; thickness of valve, 10 mm.

Observations.—The principal points of difference between *G. maudensis* and *G. cainozoica*, which at first we had been inclined to regard as variety and species, are incorporated in the above

diagnosis. There are, however, so many differential points that a further study has convinced us that it is better to regard it as a well-defined species.

Occurrence.—Janjukian (Miocene): holotype and a second example from Maude (lower beds), Moorabool River, Victoria, in Dennant coll., Nat. Museum.

GLYCYMERIS TENUICOSTATA, Reeve sp.

(Pl. II., Figs. 14, 15a, 15b; Pl. IV., Figs. 10, 11.)

Pectunculus tenuicostatus, Reeve, 1843, Proc. Zool. Soc. Lond., p. 80. *Idem*, 1843, Conch. Icon., Vol. I., Pl. VI., Fig. 35. Lamy, 1912, Journ. de Conch., Vol. LIX., pp. 105, 106, Pl. III., Fig. 3.

Glycymeris tenuicostata, Reeve, Gatliff and Gabriel, 1910, Proc. Roy. Soc. Vict., Vol. XXIII. (N.S.), Pt. I., p. 97.

Description of 1st Plesiotype (Janjukian).—Right valve, sub-circular in outline, moderately inflated, with subacute umbo. Surface ornamented with about 40 riblets, which towards the median area are alternately large and small; these are traversed by fine thread-like lines of growth, which become beaded where they cross the radial costæ; growth stages few and inconspicuous. Hinge area narrow, but slightly stouter than in Recent examples of the same size; hinge teeth slender, slightly arcuate, 11 and 10 in anterior and posterior series. Denticulæ of inner ventral margin somewhat stronger than in corresponding living forms.

Dimensions of 1st Plesiotype.—Length (ant.-post.), 14 mm.; height, 13 mm.; thickness of valve, 4.5 mm.

Description of 2nd Plesiotype (Werrikooian).—Left valve of a gerontic example; subangularly rounded, moderately inflated and with subacute umbo. Radial ornament consisting of about 44 riblets, of which the larger in the median area are carinate and more pronounced than in the Janjukian plesiotype, the secondary riblets becoming more prominent towards both extremities. The concentric ornament is virtually restricted to the intercostal spaces, where it gives rise to an incipient tegulation. Cardinal area broad; teeth straight to slightly arcuate, especially on anterior, numbering 12 and 11 on anterior and posterior series. Denticulation of ventral edge strongly marked.

Dimensions of 2nd Plesiotype.—Length (ant.-post.), 29 mm.; height, 26.5 mm.; thickness of valve, 8.5 mm.

Observations.—Examples in the Dennant coll. from Skinner's, Mitchell River, one of which we describe as plesiotype, agree in essentials with Recent shells from Cape Pillar and Oyster Bay, Tasmania, and the range of the species from Janjukian to the present day is noteworthy. One Kalimnan record is at present known to us, while it is of rare occurrence in the Werrikooian shell beds of the Glenelg River, being represented by a worn

example in the Dennant coll., and by a well-preserved shell collected by one of us (F.A.S.), here taken as a second plesiotype. These latter examples attain much larger dimensions than the Janjukian forms, while the costate ornament is more strongly developed and shows a distinct carination, but all these features are seen in a Recent Australian shell, without precise locality, in the National Museum collection.

Occurrence.—Janjukian (Miocene): plesiotype and other specimens from Skinner's, on Mitchell River, near Bairnsdale, Victoria, in Dennant coll. Nat. Museum.

Kalimnan (Lower Pliocene): Beaumaris, near Cheltenham (Dennant coll.).

Werrikooian (Upper Pliocene): Glenelg River, near Lime-stone Creek, Victoria, plesiotype coll. and pres. to Nat. Mus. by F. A. Singleton, also Dennant coll.

Recent: not uncommon in Tasmanian waters; also eastern coast line of Australia from Victoria to Queensland.

GLYCYMERIS CONVEXA, Tate sp.

(Pl. II., Figs. 16a, 16b, 17, 18, 19, 20; Pl. IV., Figs. 12, 13.)

Pectunculus convexus, Tate, 1886, Trans. Roy. Soc. S. Austr., Vol. VIII., p. 138, Pl. XI., Figs., 7a,b. Harris, 1897, Cat. Tert. Moll. Brit. Mus., Pt. I., Australasia, p. 342.

Glycymeris maccoyi, Johnston sp., Chapman and Gabriel, 1914, Proc. Roy. Soc. Vict., Vol. XXVI. (N.S.), Pt. II., p. 304, Pl. XXIV., Fig. 5 (*non* 1-4). Chapman, 1916, Rec. Geol. Surv. Vict., Vol. III., Pt. IV., Pl. LXVII., Fig. 5 (*non* 1-4).

Description by Tate, 1886: "Shell solid. Orbicular, but slightly transverse, tumid; sub-equilateral, umbones approximate, radiately ribbed. Ribs about 24, rounded, elevated, interspaces concave, wider than the ribs, crossed all over with thick concentric wavy laminae becoming finer towards the front. Inner margin of valves strongly crenate. Cardinal teeth about ten on each side.

Dimensions.—Length, 31 mm.; width, 33 mm.; thickness through both valves, 22 millimetres.

This species has some resemblance to the recent *P. flabellatus*, T. Woods, but is more inflated and with wider interspaces between the ribs."

Note on Tate's Metatypes:—The tablet in the Tate Museum, University of Adelaide, carries 16 specimens, the top row of four being gerontic, the middle row of five neanic, and the bottom row of seven practically in the ephebic stage. The second from the right in the top row, indicated by Tate as the figured specimen, and here taken as holotype, is a left valve in the gerontic stage, damaged on the ventral margin but restored in Chidley's drawing, which by the way was reversed. In addition to re-figuring the

holotype in external and umbonal aspects, we give figures of the umbonal aspect of the more convex form adjoining on the left, as well as the internal aspect of the specimen to the right; all three being left valves. The variation in convexity is well shown by their respective length, height, and thickness, which are 34, 32 and 12.5 mm.; 30, 29, and 15 mm.; and 30, 29.5 and 10 mm. We also figure (Pl. II., Fig. 19) one of Tate's juvenile examples which we regard as typical.

Observations.—Harris, in his description of the Muddy Creek specimens, refers to the small ligamental area and the strongly crenulated inner margin of the valve (*loc. supra cit.*, p. 342). The same author, in making a comparison with *Glycymeris flabellata*, T. Woods sp. (a Werrikooian and Recent species), adds to Tate's points of difference the observation that the ligamental area is much smaller in Tenison Woods' species.

The typical *G. convexa*, with its 24 ribs and strongly arched valves, appears in the neanic stage to run on the one hand into *G. planiuscula* by the flattening of the shell and the straightening of the hinge-line; whilst on the other there are passage forms into *G. decurrens*, in which the number of ribs, however, is about 30, as in *G. planiuscula*, the ribs are closer together, and the dorsal line has sloping shoulders, thus making the umbo more salient, and the outline generally subtrigonal. In adult specimens there is no difficulty in separating these three related species.

The diminutive shell from the Kalimnan of Muddy Creek figured by Chapman and Gabriel (*loc. cit.*) as *G. maccoyi*, is regarded by us as a juvenile example of *G. convexa*, in which the number of ribs is rather greater, and the degree of inflation somewhat less, than in typical examples of this species. It is here refigured (Pl. II., Fig. 20) for comparison with the more typical juvenile shell from Tate's tablet. With one exception, referred to *G. planiuscula*, the records of *G. maccoyi* from the Mallee Bores are here attributed to *G. convexa*.

Shells from the upper beds of the Adelaide Tertiary basin, as cut in the Abattoirs and other bores, show a certain amount of variation from the Muddy Creek topotypes, the South Australian examples being in general more depressed and with distinctly flattened ribs. The concentric ornament is also more developed as a series of undulose growth lines which cross the quadrately depressed ribs. This form makes a decided approach to a variant of *G. flabellata* found in South Australian waters (*vide postea*), and it may be noted that this intermediate form occurs in beds which were regarded by Tate as intermediate in age between those of Muddy Creek (Kalimnan) and the Limestone Creek shell beds (Werrikooian), although they are here classed with the former.

Occurrence.—Janjukian (?) (Miocene, probably high in series): Rose Hill, near Bairnsdale, Victoria (mould, coll. F. A.

Cudmore). The record by Tate and Dennant of this species from Camperdown requires confirmation before acceptance.

Kalimnan (Lower Pliocene): holotype from upper beds, Muddy Creek, in Tate coll., Adelaide University (also T. S. Hall and F.A.S. colls.); Forsyth's, Grange Burn (Dennant, Hall, F.C. and F.A.S. colls.); Beaumaris (Cudmore coll.); Jimmy's Point, Kalimna (doubtful identification, Dennant coll.); Mallee Bores, No. 5, at 162'-163'; No. 8, at 165'-180' (juv.), 199'-204' (frag.), and 204'-210' (juv.); No. 9, at 254'-256' (juv.), and in a mixed Kalimnan and Janjukian fauna at 235' in the Paynesville Bore, in Nat. Mus. coll., Victoria. Mindarie (W. J. Kimber coll.); Abattoirs Bore (Kimber and Cudmore colls.), Adelaide, South Australia. This species is also listed by Tate from Tareena, N.S.W., and from the upper series (oyster beds), at North-west bend on the River Murray, Dry Creek Bore (var.) and at Aldinga (upper beds), and Hallett's Cove, South Australia; and by Dennant, from Horsham, Victoria.

GLYCYMERIS SUBRADIAN, Tate.

(Pl. III., Figs. 21, 22; Pl. IV., Fig. 14.)

Glycymeris subadians, Tate, in Basedow, 1902, Trans. Roy. Soc. S. Austr., Vol. XXVI., Pt. II., p. 132. Chapman, 1915, Geol. Surv. S. Austr., Bull. No. 4, p. 48.

Description in Basedow, 1902.—“This species is of the same general outline as *G. radians*, Lk., but differs by being flatter and having its radial ribs more acutely elevated, the interspaces being as wide. The radial ornamentation, moreover, is obsolete on the lateral slopes.”

Observations.—This species has not been figured hitherto, but one of us has amplified the brief original diagnosis by the following description (Chapman, *loc. cit.*) of a specimen from Hallett's Cove, now in the Dennant coll. at the National Museum.—“Outline of valve subcircular, slightly longer than high; surface of valve depressed, especially near the umbo. Cardinal area as in *G. radians*, with teeth, nine on each side, slightly thicker. Exterior of valve ornamented with about 50 depressed riblets, vertically striated. Dimensions of shell from Hallett's Cove: Length, 16 mm.; height, 14.75 mm.; depth of valve, measured externally, 5 mm.

Observations.—The chief points of difference between the living *G. radians* and the present form are the depressed shape of the valve and the more numerous ribs, circ. 50 against (*sic*) circ. 40 in the living species.”

Upon application being made to Dr. H. Basedow for the loan of the type specimen, we were informed that it should be in the Tate Museum, University of Adelaide. A search in the Tate collection on our behalf by Sir Douglas Mawson proved unsuc-

cessful, so that in the absence of the type, which has never been figured, we are compelled to illustrate the species by means of an imperfect example from Marino, near Hallett's Cove, loaned to us by Dr. Basedow. In addition, we figure the shell from Hallett's Cove from which the above supplementary description was made.

In dealing with *G. striatularis* we record our belief that that species is more closely related to *G. subradians* than is *G. radians*, Lamarck sp.,¹⁶ the fossil history of which is as yet unknown to us. In view of the confusion which has existed in respect to the identification of the two Lamarckian species,¹⁷ it is not improbable that the Recent species with which the fossil was compared was actually *G. striatularis*, and erroneously named *radians*.

Occurrence.—Kalinman (Lower Pliocene): holotype from Hallett's Cove, present location of type unknown (also Dennant and F.A.S. colls.); Marino (Basedow coll.); Abattoirs and Dry Creek Bores, Adelaide (W. J. Kimber coll.), South Australia. Beaumaris, Victoria (Dennant coll.). Also recorded by Basedow from Edithburg, Yorke's Peninsula, S.A.

GLYCYMERIS HALLI, Pritchard.

(Pl. III., Fig. 23; Pl. IV., Fig. 15.)

Glycymeris halli, Pritchard, 1903, Proc. Roy. Soc. Vict., Vol. XV. (N.S.), Pt. II., pp. 89-91, Pl. XIV., Figs. 10-12; Pl. XV., Figs. 1, 2, 8, 9.

Description by Pritchard, 1903: "Shell orbicular, tumid, thick and strong, equilateral, with a prominent convex umbo, and closely radially ribbed surface. Umbo incurved and overhanging the ligamental area, which is a well-defined isosceles triangular space, the base of which is just about half the width of the hinge. Hinge furnished with from 22 to 26 oblique and angular teeth, most usually 12 on each side, with a tendency for the medial ones to become obsolete in the extreme adult. Surface closely covered with broad radial ribs, ranging from about 30 to 35 in small specimens, up to about 50 in the adult, ribs slightly convex, with very narrow, almost lineal, interspaces in young shells, but in the adult the ribs are decidedly flattened; the ribs are closely, finely, and regularly radially striate, each rib bearing near the ventral margin ten striae, anteriorly and posteriorly the ribs become obsolete, but the radial striae are present, and much stronger than on the ribs. The radial sculpture is crossed by fine concentric lines of growth. Interior of valves strongly denticulate along

16.—*Pectunculus radians*, Lamarck, 1819, Anim. s. vert., Vol. VI., Pt. I., p. 54, No. 18. Reeve, 1843, Conch. Icon., Vol. I., Pt. IX., Figs. 30a, b. Lamy, 1912, Journ. de Conch., Vol. LIX., pp. 111, 112.

17.—cf. Tate, 1897, Trans. Roy. Soc. S. Austr., Vol. XXI., Pt. I., p. 48. Pritchard and Gatliff, 1904, Proc. Roy. Soc. Vict., Vol. XVII. (N.S.), Pt. I., p. 244.

the ventral margin, bearing about 25 strong denticles, running about 8 to 10 in 10 mm., thence both anteriorly and posteriorly diminishing in size, but extending right up to the hinge. . . .

Dimensions.—Type, antero-posterior diameter, 42 mm.; umbo-ventral diameter, 44 mm.; thickness through one valve, 18 mm. Others range from 24 by 22, 21 by 20, 18 by 17, 17 by 16, 12 by 11, to 9 by 9 and 8 by 8, and smaller."

Observations.—Pritchard, in making a comparison with topotypes of *G. cainozoica* states (*loc. supra cit.*, p. 91, that examples of *G. halli* are "much thicker and stronger, more convex, with coarser radial ribbing, but much finer radial striations."

The greater heaviness of the shell and in particular of the hinge-line, which is more arcuate than in *G. cainozoica*, afford the easiest means of recognition of this species, the type material of which is in the private collection of Dr. G. B. Pritchard. Typical examples from MacDonald's, Muddy Creek, average 25 mm. in length, but occasional gerontic shells, one of which we figure, attain larger dimensions. The largest known to us (coll. T. S. Hall, in Cudmore coll.), measures 54.5, 54.5, and 21 mm. in length, height and thickness of valve respectively; while the corresponding dimensions of the shell here figured are 49, 48 and 18 mm.

Occurrence.—Kalimnan (Lower Pliocene): holotype from Forsyth's, Grange Burn, in Pritchard coll. (also T. S. Hall, Nat. Mus., and F.A.S. colls.); MacDonald's, Muddy Creek, plesiotype in Nat. Mus. coll., pres. R. Hughan (also Hall, F.C. and F.A.S. colls.); nodule bed between Clifton Bank and MacDonald's (F.C. coll.); Beaumaris (Dennant coll.); Jimmy's Point, Kalimna (Dennant, Hall and F.A.S. colls.); and Mallee Bore Nos. 1 (208'-210'), 2 (198'-200'), 4 (163'-170'), 5 (163'-175', 175'-189'), 6 (114'-150', 154'-158', 158'-161'), 8 (165'-180', 180'-199', 199'-204', 204'-210', 225'-226'), 9 (263'-273', 315'-325), Maryvale Bore, upper beds at Portland, and from a mixed fauna at 265' in the Paynesville Bore, Victoria (all in Nat. Mus. coll.).

GLYCYMERIS HALLI, var. INTERMEDIA, Pritchard.

Glycymeris halli, var. *intermedius*, Pritchard, 1903, Proc. Roy. Soc. Vict., Vol. XV. (N.S.), Pt. II., p. 90, Pl. XIV., Figs. 10, 11.

Description by Pritchard, 1903: "A variation of the above shows a less orbicular outline with sloping shoulders and consequently an apparently more prominent umbonal region, and with coarser (*sic*) radial ribbing, 25 to 28 being about the average number. . . .

Dimensions.—Var. *intermedius*, antero-posterior diameter, 21 mm., umbo-ventral diameter, 20 mm., and 19 by 19."

Observations.—Since Dr. Pritchard has given good figures of this and the succeeding variety, we have not here depicted them.

This form appears to be the commoner of the two varieties in the Muddy Creek area, but the type form (*G. halli*, s. str.) is far more abundant than either.

Occurrence.—Kalimnan (Lower Pliocene): type of var. from MacDonald's, Muddy Creek, in Pritchard coll.; Forsyth's, Grange Burn (T. S. Hall coll.); Beaumaris (Cudmore coll.); Jimmy's Point, Kalimna (Dennant coll.); Mallee Bores Nos. 3 (201'-220'), 5 (155'-159', 162'-163', 175'-189'), 6 (114'-150', 154'-158', 158'-161'), 8 (165'-180', 199'-204', 204'-2108'), 9 (254'-273', 315'-325'), 10 (254'-296') (Nat. Mus. coll.), Victoria.

GLYCYMERIS HALLI, var. PAUCICOSTATA, Pritchard.

Glycymeris halli, var. *paucicostatus*, Pritchard, 1903, Proc. Roy. Soc. Vict., Vol. XV. (N.S.), Pt. II., p. 90, Pl. XIV., Fig. 12; Pl. XV., Fig. 9.

Description by Pritchard, 1903: Another form which appears but a variation of the above species, is intermediate in shape between it and the foregoing variety, but rather closer related to the latter, being distinguished most readily by the coarser radial ribbing, as it bears only about 20 strong, convex ribs, neglecting the obscure and ill-defined ones on the anterior and posterior slopes.

Dimensions.—Var. *paucicostatus*, antero-posterior diameter, 22 mm.; umbo-ventral diameter, 21 mm.; others range about 18 by 17, and 15 by 14.5."

Observations.—This variant is apparently the rarest of the three forms, although, as remarked by Pritchard, it is not uncommon at the type section of the Kalimnan at Jimmy's Point, Gippsland Lakes.

Occurrence.—Kalimnan (Lower Pliocene): type of var. from Jimmy's Point, Kalimna, near Lakes Entrance, in Pritchard coll. (also Dennant and F.A.S. colls.); Forsyth's, Grange Burn (T. S. Hall coll.); Mallee Bore No. 8, 165'-180' (Nat. Mus. coll.), Victoria.

GLYCYMERIS DECURRENS, sp. nov.

(Pl. III., Figs. 24a, 24b, 25a, 25b; Pl. IV., Fig. 16.)

Description of Holotype.—Right valve of an adult specimen; subtrigonal in outline, moderately depressed; ventral border angularly rounded; dorsal line short. Umbo minute, prominent and acute, distinctly opisthogyrate. Surface evenly rounded except towards the posterior margin, where it becomes distinctly flattened. Costae about 31, evenly radiate, depressed and slightly rounded, with linear interspaces; lines of growth well marked, increasing towards the ventral border; growth stages rather numerous, about 9 in the holotype. Hinge area moderately deep, angularly arched; teeth fairly strong, about 13 on each side. Denticulae of inner margin well marked and excavate opposite to the external costae.

Dimensions of Holotype.—Length (ant.-post.), 22.5 mm.; height, 23 mm.; thickness of valve, 6.5 mm.

Description of Paratype.—This is a left valve of an ephebic example, which differs from the holotype in its more rounded outline, less arched dorsal margin, less prominent umbo, and somewhat flatter valve. The costae, about 29 in number, are similar to those of the holotype, while the distinctness of the growth stages is also common to both.

Dimensions of Paratype.—Length (ant.-post.), 18.5 mm.; height, 17.25 mm.; thickness of valve, 4 mm.

Observations.—This Kalimnan form has long been referred to *G. subtrigonalis*, Tate sp., and it is only after full consideration that we accord to it specific rather than varietal rank. The present species differs from *G. subtrigonalis*, however, in the greater depression of the shell; the flattening of the ribs, which become almost obsolete towards the umbo; and the finer interspaces, which are practically linear, as opposed to those of *G. subtrigonalis*, in which the intercostal spacing is well marked and even sulcate.

Of living species *G. sordida*, Tate sp.¹⁸ of the southern coasts of Australia bears the most resemblance, but is readily distinguished from *G. decurrens* by its fewer ribs (20 as against 31 in the respective holotypes), and characteristic stepping of the shell surface due to rest-periods during growth.

Occurrence.—Kalimnan (Lower Pliocene): Forsyth's, Grange Burn, near Hamilton, Victoria, holotype pres. to Nat. Mus. by F. A. Singleton, paratype coll. and pres. by F. Chapman (also T. S. Hall coll.); Jimmy's Point, Kalimna (Dennant coll.), Victoria.

GLYCYMERIS PLANIUSCULA, sp. nov.

(Pl. III., Figs. 26, 27, 28; Pl. IV., Figs. 17, 18.)

Pectunculus planiusculus, Tate MS., in Dennant, 1887, Trans. Roy. Soc. Vict., Vol. XXIII., p. 237 (list name).

Description of Holotype.—Right valve of a medium-sized specimen; sub-circular in outline, depressed; ventral border evenly rounded; dorsal line straight and extensive, longer on the anterior side; anterior margin less evenly rounded than posterior, the latter being circularly convex from the ventral to the post-dorsal angle. Umbo minute, acute and slightly opisthogyrate. General surface depressed gently and evenly on the ventro-dorsal axis; flattened at the anterior and posterior regions. Costae about 34, rounded and rather depressed, with linear interspaces, and crossed by fine thread-like lines of growth; the ribs on the anterior are rounder and more definite than those on the posterior. This speci-

18.—*Pectunculus sordidus*, Tate, 1891, Trans. Roy. Soc. S. Austr., Vol. XIV., p. 264, Pl. XI., Fig. 8. *Glycymeris sordidus*, Tate, Verco, 1907, *ibid.*, Vol. XXXI., pp. 227, 228.

men shows about five growth stages marked by deeper concentric lines. Hinge area comparatively deep and flat, the entire internal margin having a strongly planated character. Teeth strong, oblique, numbering about 8 on each side. Inner marginal denticulate and excavate in opposiiton to the external costae.

Dimensions of Holotype.—Length (ant.-post.), 19.5 mm.; height, 16.5 mm.; thickness of valve, 3 mm.

Since the preservation of the holotype is not quite perfect, we may amplify the above description by means of other and better specimens from the Kalimnan beds of the Upper Muddy Creek Series, one of which we select as a paratype.

Description of Paratype.—This is a left valve which shows the following additional features:—Costation at post-cardinal angle rather more widely spaced than anteriorly. Ligamental area small, striated.

Dimensions of 1st Paratype.—Length (ant.-post.), 11.5 mm.; height, 11 mm.; thickness of valve, 2 mm.

Description of Gerontic Form (Paratype).—Valve roundly oval, longest diameter dorso-ventral. Costæ about 32, rounded and depressed. Cardinal area typically flat, with 8 teeth on each side. Striated ligamental area limited and small.

Dimensions of 2nd Paratype.—Length, 32.5 mm.; height, 34 mm.; thickness of valve, 6.5 mm.

Observations.—This species name has been known since 1887, when Mr. Dennant introduced it as a MS. name of Prof. Tate's into a list of fossils from the Glenelg River. In the Dennant coll. now in the National Museum are three examples to which Tate's MS. name has been attached, one of which, the most typical, we select as holotype. Of the remaining two specimens, one is a neanic form, somewhat damaged, whilst the other is a gerontic form, of somewhat aberrant character in its accentuated height along the dorso-ventral axis.

It may be noted that the specimen recorded by Chapman and Gabriel¹⁹ from the Mallee Bore No. 6, 158'-161', as *G. maccoyi*, is now referred by us to the above species.

The characteristic planation of the internal margin is a character shared by the Recent *G. vitrea*, Lamarck sp.²⁰, of the Queensland coast, a species which is similar in outline but differs in the greater number of ribs (40 as against 34) in the living form, while the surface ornament is entirely different.

Occurrence.—Kalimnan (Lower Pliocene): paratype (coll. and pres. to Nat. Mus. by F. Chapman) and other specimens from Forsyth's, Grange Burn (also T. S. Hall and F.A.S. colls.); from the same horizon at MacDonald's, Muddy Creek, near Hamilton (F.C. coll.); Mallee Bore No. 6, 158'-161' (Nat. Mus. coll.), Victoria.

19.—Proc. Roy. Soc. Vict., Vol. XXVI. (N.S.), Pt. II., 1914, p. 304.

20.—*Pectunculus vitreus*, Lamarck, 1819, Anim. s. vert., Vol. VI., Pt. I., p. 54. Reeve, 1843, Conch. Icon., Vol. I., Pl. VIII., Figs. 45a,b. Lamy, 1912, Journ. de Conch., Vol. LIX., pp. 94, 95.

Werrikooian (Upper Pliocene) : holotype and paratype (gerontic form), from Limestone Creek, Glenelg River, Victoria, in Dennant coll., Nat. Museum (also F.A.S. coll.).

GLYCYMERIS FLABELLATA, T. Woods sp.

(Pl. III., Figs. 29a, 29b, 30; Pl. IV., Figs. 19, 20.)

Pectunculus flabellatus, T. Woods, 1878, Trans. Roy. Soc. Vict., Vol. XIV., pp. 61, 62. Harris, 1897, Cat. Tert. Moll. Brit. Mus., Pt. I., Australasia, p. 342.

Glycymeris flabellatus, T. Woods sp., Pritchard and Gatliff, 1904, Proc. Roy. Soc. Vict., Vol. XVII. (N.S.), Pt. I., pp. 242, 243. Gatliff and Gabriel, 1908, Proc. Roy. Soc., Vict., Vol. XXI. (N.S.), Pt. I., p. 391.

Glycymeris pectinoides, Deshayes, Verco, 1907, Trans. Roy. Soc. S. Austr., Vol. XXXI., pp. 226, 227, Pl. XXVIII., Fig. 4 (*non* Deshayes).

Description by T. Woods, 1878: "Shell broadly orbicular, *but slightly transverse*, thick, somewhat tumid, validly radiately ribbed; *ribs 25 to 35, broad, flattened*, becoming very close at the sides as the shell grows; margins broadly toothed; cardinal teeth 16 to 20, white; colour white stained, but intense fulvous brown within, and more or clouded and spotted with the same colour on the outside.

Long. 44, Lat. 47, Alt. 44."

Description of Neotype.—A left valve, subcircular, solid, and moderately inflated, with inconspicuous umbo. Surface ornamented with 24 broad, rounded and somewhat flattened ribs, with almost linear interspaces. Concentric ornament ill-defined, consisting of fine liræ; growth stages well marked, about seven in number. Hinge-line regularly arched, with eight straight teeth in each of anterior and posterior series. Ligament area narrow, with 4 and 5 striae respectively in a space of 1.5 mm.

Dimensions of Neotype.—Length (ant.-post.), 37 mm.; height, 34 mm.; thickness of valve, 10 mm.

Description of Plesiotype.—The fossil specimen here figured differs from the Recent neotype in having a more ovate outline, being higher than long, in which character, however, the fossil shell can be matched among Recent examples. The ribs number about 23, and the other shell characters are similar to those of the neotype.

Dimensions of Plesiotype.—Length, (ant.-post.), 36 mm.; height, 37 mm.; thickness of valve, 9.5 mm.

Note on T. Woods' Type.—Tenison Woods (*loc. cit.*) gives the distribution as "Victoria and Tasmania," and the specimen on which he based his original description should be in the collections of the National Museum, Melbourne, but so far we have been unable to identify it from the dimensions given.

We have, therefore, selected as neotype one of a pair of valves from N.E. Tasmania in the Nat. Mus. coll. The label is dated 1877, and the tablet is believed to be one of those examined and named by T. Woods at the time of writing of his paper.

Observations.—This Recent species found off the south-eastern coasts of Australia shows considerable variation in outline, degree of inflation and character of the radial and concentric ornament, all of which features have been fully dealt with by Verco (*loc. supra cit.*). It is noteworthy that the fossil shells agree with the neotype here selected in having narrow interspaces and poorly developed concentric ornament, as contrasted with the variant having deeply furrowed interspaces and squamose concentric ornament, which is not uncommon in South Australian waters. This latter form is frequently decidedly inequilateral in addition; nevertheless we agree with Verco in believing that the lack of fixity of these characters precludes the erection of varietal distinctions.

Occurrence.—Werrikooian (Upper Pliocene): Glenelg River near Limestone Creek, Western Victoria, plesiotype and other examples in Dennant coll., Nat. Mus.; also F.A.S. coll.

Recent: somewhat uncommon in Victorian, Tasmanian and South Australian waters.

GLYCYMERIS STRIATULARIS, Lamarck sp.

(Pl. III., Fig. 31; Pl. IV., Fig. 21.)

Pectunculus striatularis, Lamarck, 1819, Anim. s. vert., Vol. VI., Pt. I., p. 52, No. 13. Lamy, 1912, Journ. de Conch., Vol. LIX., pp. 112-14, Pl. II., Figs. 1, 2.

Pectunculus obliquus, Reeve, 1843, Conch. Icon., Vol. I., Pl. VI., Fig. 33.

Glycymeris striatularis, Lamarck, Pritchard and Gatliff, 1904, Proc. Roy. Soc. Vict., Vol. XVII. (N.S.), Pt. I., p. 244. *Idem, ibid.*, 1906, Vol. XVIII. (N.S.), Pt. II., p. 68.

Description of Plesiotype.—Right valve of an ephebic example, subovate, moderately inflated, with minute but conspicuous umbo. Shell surface marked with numerous depressed radial ribs, about 25 in the median area, where they are separated merely by shallow linear sulci, but gradually disappearing anteriorly and posteriorly. Each rib carries about 8 longitudinal striae, partially interrupted by the concentric growth lines but persisting as fine radii on either margin, where the costae have become obsolete; growth stages numerous but ill-defined. Hinge area gently arcuate; teeth 13 and 12 in anterior and posterior series, slightly uncinately centrally but becoming more linear marginally; ligamental area with about 3 striae in a space of 1.8 mm. Inner ventral margin with about 37 denticulae, which become smaller and ultimately vanish anteriorly and posteriorly.

Dimensions of Plesiotype.—Length (ant.-post.), 34 mm.; height, 31 mm.; thickness of valve, 9.5 mm.

Observations.—In his original description of the shell beds of the Glenelg River near the junction of Limestone Creek, in South-Western Victoria, Dennant²¹ listed on Tate's determination *Pectunculus obliquus*, Reeve, now a synonym of *G. striatularis*, Lamarck sp., to which we refer the common species of *Glycymeris* in these Werrikooian deposits. At a later date he listed²² the form under the name of *G. radians*, Lamarck, a species which has suffered much confusion with *G. striatularis*. An examination of the examples from Limestone Creek in the Dennant coll., now in the National Museum, induces us to refer all but one to *G. striatularis*, of which a large series has recently been obtained by one of us (F.A.S.) from the Werrikooian shell-beds of the Glenelg River. The solitary exception is regarded by us as a worn example of *G. tenuicostata*, Reeve sp.

These Werrikooian examples of *G. striatularis* agree well with the Recent shells as found along the southern coasts of Australia. A related fossil form is that described as *G. subadians*, which appears to be closer to the present species, *G. striatularis*, than to the Recent *G. radians*.

Occurrence.—Kalinman (Lower Pliocene): Beaumaris, V., and Abattoirs Bore, S.A., F. A. Cudmore coll. (*G. cf. striatularis*. At both localities).

Werrikooian (Upper Pliocene): Glenelg River near Limestone Creek, Victoria, plesiotype in Dennant coll., Nat. Mus.; also T. S. Hall (pres. E. B. Brown), and F.A.S. colls.

Post-Tertiary: Outer Harbour, Adelaide, South Australia (F.A.S. coll., pres. W. J. Kimber).

Recent: common along southern coastline of Australia from Western Australia to Victoria; also Tasmania.

GLYCYMERIS AUSTRALIS, Quoy and Gaimard sp.,
var. GIGANTEA, Chapman.

(Pl. III., Fig. 32; Pl. IV., Fig. 22.)

Glycymeris australis, Quoy and Gaimard sp., var. *gigantea*,
Chapman, 1915, Geol. Surv. S. Austr., Bull. No. 4,
p. 49.

Description by Chapman, 1915: "The outline of the shell is sub-orbicular to suboval, and longer than deep. The faint radial ornament links it up with *G. radians*, Lam. sp., but in its general characters, and especially in its concentric folds, it agrees with *G. australis*, excepting that the size and thickness of the valves are much greater than in the living species. The concentric lines of growth, moreover, are in this variety strongly developed near the

21.—Dennant, 1887, Trans. Roy. Soc. Vict., Vol. XXIII., p. 237.

22.—Dennant and Kitson, 1903, Rec. Geol. Surv. Vict., Vol. I., Pt. II., p. 146.

ventral border, where they form distinct rugæ. The form of the valve in being longer than high is like that of other Australian species, thus differing from *G. laticostatus*, Q. and G., which shell it resembles in its massive character. The fractured shell shows a thickness of 5 mm. in several instances."

Observations.—This variety of the Recent *G. australis*, Q. and G. sp.,²³ was founded on some more or less fragmentary shells obtained by Dr. Arthur Wade at Kangaroo Island, and we take the opportunity of furnishing a figure of the type of the variety, and of making some additional observations upon it. It is worthy of note that this form does not occur in the large and typical series of Werrikooian fossils from the Glenelg River made by Mr. Dennant, and now in the National Museum.

On account of certain aberrant features of the type specimen, notably in the distinctly rugose character of the shell-surface, we have re-examined it in conjunction with Mr. C. J. Gabriel, and furnish the following remarks:—

Notes on the Holotype.—This is a left valve in the gerontic stage. The outline is markedly equilateral, and in the earlier stages longer than high, but in the present gerontic form this relation appears to be reversed. The umbo is relatively minute and opisthogyrate. Decortication of the external rugose layer results in the display of faint radial lineations, and in a few places there are indications of a finely undulose growing edge. The interior is filled by the hard and resistant matrix, by which the hinge characters are largely masked, but so far as seen they are in accord with *Glycymeris*. The thickness of the shell in the type example is considerably less than the 5 mm. indicated in the original diagnosis, and does not exceed 2.5 mm. The approximate dimensions of the imperfect shell are:—Length (ant.-post.), 72 mm. (restored); height, 85 mm.; thickness of valve, *circa* 24 mm.

Occurrence.—Werrikooian (Upper Pliocene): Vivonne Bay, Kangaroo Island, South Australia, holotype of variety, coll. Dr. Wade, in the National Museum, Melbourne.

23.—*Pectunculus australis*, Quoy and Gaimard, 1835, Voy. Astrolabe, Vol. III., pp. 469, 470, Pl. LXXVII., Figs. 7-9.

RANGE IN TIME OF SPECIES

	Balcombian (Oligocene)	Janjukian (Miocene)	Kalinan (L. Pliocene)	Werrikooian (U. Pliocene)	Post Tertiary	Recent
"Awinea" group -	..	maudensis.				
	cainozoica	cainozoica				
	halli halli intermedia. halli paucicostata.	australis gigantea	..	australis.
	striatularis (?) subradians tenuicostata	striatularis	striatularis	striatularis. radians. tenuicostata.
"Laticostata" group -	..	ornithopeira.	..	..	..	laticostata (N.Z.).
	..	maccayi.				
	..	lenticularis	planuscula	planuscula.		
	gunyoungensis	gunyoungensis.				
..	..	subtrigonalis	decurrens	..	..	sordida.
..	..	convexa (?)	convexa	flabellata	..	flabellata.

SYNOPSIS OF SPECIFIC CHARACTERS.

	Shape of Valve.	Profile.	Umbo	Costation.	Growth Lines.	Growth Stages.	Inner Dorsal Region.	Inner Ventral Region.
<i>G. canosotica</i>	roundly trigonal to subcircular; oblique in gerontic stage	strongly convex	prominent; acute, incurved	faint radii	concentric striae	numerous, not strongly marked	ligament moderately broad, 6-8 striae; hinge line arched, teeth 8:7 ephebic, 13:12 gerontic	finely denticulate; margin defined, not extensive
<i>G. maudensis</i>	subtrigonal	moderately convex	subacute, prominent	striate; obsolescent towards ventral border	fine	inconspicuous	ligament area arcuate; teeth 9.8	strongly denticulate
<i>G. halli</i>	circular	strongly convex dorsally; depressed ventrally	large, incurved	ribs broad, radially striate, 30-50, interspaces sublinear	fine concentric lines	few and indistinct	ligament area moderately long, about 8 striae; teeth circ. 12:12.	edge thick, denticulate
<i>G. halli intermedia</i>	subcircular; marked umbonal truncation	ditto	ditto	ribs 25-28	ditto	ditto	ligament area short, about 6 striae; teeth circ. 10:10	ditto
<i>G. halli paucicostata</i>	subcircular	ditto	smaller than in sp. type; incurved	20 strong convex ribs, narrow interspaces.	fine undulate striae	ditto	ligament area short, about 4 striae	ditto

SYNOPSIS OF SPECIFIC CHARACTERS—(Continued).

	Shape of Valve.	Profile.	Umbo.	Costation.	Growth Lines.	Growth Stages.	Inner Dorsal Region.	Inner Ventral Region.
<i>G. australis</i>	subcircular to subovate, transverse	convex at umbo	small, incurved	about 34 depressed ribs, finely striate, with fine linear interspaces	fine, almost obsolete	few, indistinct	ligament area moderately long, slightly non-striate	edge flatly rounded, with fine denticulae.
<i>G. australis gigantea</i>	ditto	evenly convex	ditto	striate	distinct, well-developed at ventral margin.	ditto	ditto	—
<i>G. striatularis</i>	subovate	moderately convex at umbo	small, acute	about 25 depressed ribs in median area; finely striate	fine	numerous, indistinct	ligament area small, striae few; teeth circ. 13:12.	finely denticulate
<i>G. subadians</i>	subcircular, slightly transverse	moderately convex	small	50 depressed striated ribs	fine, almost obsolete	few and indistinct	ligament area short and low; hinge line short; teeth circ. 7:7	feebly denticulate
<i>G. tenuicostata</i>	subcircular	depressed convex	subacute	about 40 ribs, alternately large and small	numerous, beaded	few, inconspicuous	ligament area narrow; teeth circ. 12:11	strongly denticulate

SYNOPSIS OF SPECIFIC CHARACTERS—(Continued).

	Shape of Valve.	Profile.	Umbo.	Costation.	Growth Lines.	Growth Stages.	Inner Dorsal Region.	Inner Ventral Region.
<i>G. ornithopetra</i>	subcircular in neanic and ephelic stages; in gerontic irregularly subovate, longer axis dorso-ventral	strongly convex and deep at umbo	comparatively small	40 subangular to rounded ribs; interspaces well-defined and 1/3 of a rib.	very fine, interradially as squamose laminae	numerous, well-marked, deeper crossing entire surface as undulate laminae	ligament short and high, 10 striae; teeth 8.8 in type	subplanate, denticulate in type
<i>G. maccoyi</i>	subcircular; subangulate on ventral border in gerontic stage	moderately to depressed convex	inconspicuous	29-31 convex ribs; interspaces narrow	fine concentric laminae	fairly numerous but indistinct	ligament long and low, 8 striae; hinge line moderately long; teeth 8.8 in type	area planate, with 20 denticulae in type
<i>G. lenticularis</i>	circular, slightly transverse	depressed convex	small, acute	40-50 rounded ribs, with interspaces of equal width to ribs	fine concentric undulae	fairly numerous, indistinct	ligament very small; teeth 11.11	area narrowly denticulate
<i>G. guryoungensis</i>	subcircular; subirregular dorsally	depressed convex	inconspicuous	about 33 rounded ribs; interspaces narrow	distinct and closely concentric	very distinct	ligament narrow, 4 striae; hinge line arched; teeth 11:10 in type	margin narrow, distinctly denticulate ventrally, but evanescent towards dorsal region

SYNOPSIS OF SPECIFIC CHARACTERS—(Continued).

	Shape of Valve.	Profile.	Umbo.	Costation.	Growth Lines.	Growth Stages.	Inner Dorsal Region.	Inner Ventral Region.
<i>G. subtrigonalis</i>	subtrigonal, oblique	depressed convex	small, inconspicuous	about 29 subimbricate rounded ribs; interspaces narrower but well-marked	subimbricate lamellae	few, but distinct	ligament short, low, with about 5 striae; hinge line very short, teeth in arched series, about 10:10	area strongly crenate
<i>G. decurrens</i>	circular to subtrigonal	depressed convex	small, acute	29-31 depressed ribs with fine interspaces, becoming almost obsolete near umbo	lamellae ethaphased at growth stages and towards ventral border	fairly numerous; well-marked	ligament short, about 6 striae; cardinal series arched, teeth 13:11 in type	outer edges moderately flat; denticulations well-marked
<i>G. planiuscula</i>	subcircular; higher than long in gerontic stage	much depressed	small, acute	about 34 depressed ribs with linear interspaces	fine, thread-like	few, inconspicuous	ligament small, striae few	edge flat and broad, with faint denticulae
<i>G. convexa</i>	circular, slightly transverse	deeply convex at umbos; more depressed near ventral region	small, acute	24 elevated ribs, narrower than interspaces	thick, concentric laminae, finer at anterior	few, but usually well-marked	ligament long and low, about 5 striae; teeth in arched series, about 10:10.	inner edge plane, with coarse denticulae
<i>G. flabellata</i>	subcircular	moderately convex	small, inconspicuous	about 25 rounded ribs with sulcate interspaces	fine wavy laminae	few, well-marked	ligament moderately long and low, about 3 striae; cardinal series arched, teeth 8:8	edge flat, with coarse denticulae

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For facilities in examining valuable type material we are under obligations to the University of Adelaide, through the good offices of Sir Douglas Mawson, in regard to the types in the Tate Museum; to Mr. L. Keith Ward, Government Geologist of South Australia, for allowing us to re-examine a topotype of *G. australis*, var. *gigantea* from Kangaroo Island; to the Director of the Tasmanian Museum, Hobart (Mr. Clive Lord) for the opportunity of examining the Tenison Woods material of *G. cainozoica*; and to Mr. J. A. Kershaw, Curator of the National Museum, Melbourne, for the opportunity of selecting a neotype of *G. flabel-lata* from the Tenison Woods collection.

To Mr. F. A. Cudmore we are especially indebted for generously placing the whole of his large series of fossil glycymerids at our disposal; the specimens which we have selected for types have been subsequently donated by him to the National Museum collection.

Dr. Herbert Basedow has kindly lent us his series of *G. sub-radians*, one of which we have figured as a plesiotype; while Mr. W. J. Kimber has favoured us with the loan of South Australian fossil examples of the genus from his collection. To Mr. H. J. Finlay, M.Sc., of Dunedin, and Dr. J. Marwick, of Wellington, we are also under obligations for discussions, papers on the subject and comparisons with the faunal distribution of the genus in New Zealand. Dr. G. B. Pritchard has kindly furnished us with information as to the localities of the types of *G. halli* and its varieties, originally described by him.

And lastly, we are particularly grateful to our friend, Mr. C. J. Gabriel, who has supplied us with comparative specimens of recent glycymerids from his extensive collection; a like service in respect to South Australian examples having been rendered us by Sir Joseph Verco, to whom we tender our best thanks.

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EXPLANATION OF PLATES.

PLATE I.

Fig. 1.—*Glycymeris cainozoica*, T. Woods sp. Janjukian. Table Cape. Holotype. Tasmanian Museum, Hobart. (a) exterior; (b) interior. Slightly enlarged.

- Fig. 2.—*G. cainozoica*, T. Woods sp. Janjukian. Table Cape. Paratype. Tas. Mus., Hobart. (a) exterior; (b) interior. Slightly enlarged.
- Fig. 3.—*G. cainozoica*, T. Woods sp. Balcombian. Muddy Creek, lower beds. Plesiotype. Tate Coll., Adelaide University Geol. Dept. Original of Tate's figure. Nat. size.
- Fig. 4.—*G. cainozoica*, T. Woods sp. Balcombian. Muddy Creek, lower beds. Plesiotype. Tate Coll., Adelaide University. Shell on left of Tate's figured specimen. Nat. size.
- Fig. 5.—*G. gunyoungensis*, sp. nov. Balcombian. Grice's Creek, Port Phillip. Holotype. National Museum, Melbourne; coll. W. Kershaw. (a) exterior, slightly enlarged; (b) interior, circ. nat. size. [13324.]²⁴
- Fig. 6.—*G. gunyoungensis*, sp. nov. Balcombian. Grice's Creek. Paratype. Nat. Mus.; coll. W. Kershaw. Slightly reduced. [13325.]
- Fig. 7.—*G. maccoyi*, Johnston sp. Janjukian. Table Cape. Neotype. Nat. Mus.; coll. and pres. F. A. Cudmore, (a) exterior; (b) interior. Circ. nat. size. [13326.]
- Fig. 8.—*G. lenticularis*, Tate sp. Janjukian. Adelaide Bore. Cotypes. Tate Coll., Adelaide University. (a) right valve; (b) left valve. Nat. size.

PLATE II.

- Fig. 9.—*Glycymeris ornithopetra*, sp. nov. Janjukian. Bird Rock Cliffs, Torquay. Holotype. Geol. Surv. Vict. Coll., Nat. Mus.; coll. R. Daintree. (a) exterior; (b) interior. Circ. nat. size. [12465.]
- Fig. 10.—*G. subtrigonalis*, Tate sp. Janjukian. Murray River, near Morgan. Holotype. Tate Coll., Adelaide University. Nat. size.
- Fig. 11.—*G. subtrigonalis*, Tate sp. Janjukian. Murray River, near Morgan. Plesiotype. Tate Coll., Adelaide University. Shell on left of Tate's figured specimen (holotype). Nat. size.
- Fig. 12.—*G. subtrigonalis*, Tate sp. Janjukian. Murray River, four miles below Morgan. Plesiotype. Nat. Mus.; coll. and pres. F. A. Cudmore. Internal aspect. Circ. nat. size. [13327.]
- Fig. 13.—*G. maudensis*, sp. nov. Janjukian. Maude, lower beds. Holotype. Dennant Coll., Nat. Mus. (a) exterior, circ. nat. size; (b) interior, slightly reduced. [13328.]
- Fig. 14.—*G. tenuicostata*, Reeve sp. Janjukian. Skinner's, Mitchell River. Plesiotype. Dennant Coll., Nat. Mus. Circ. nat. size. [13329.]

24.—This and succeeding numbers in brackets refer to registered specimens in the National Museum.

- Fig. 15.—*G. tenuicostata*, Reeve sp. Werrikoonian. Glenelg River, above Limestone Creek. Plesiotype. Nat. Mus.; coll. and pres. F. A. Singleton. (a) exterior; (b) interior. Slightly reduced. [13330.]
- Fig. 16.—*G. convexa*, Tate sp. Kalimnan. Muddy Creek, upper beds. Holotype. Tate Coll., Adelaide University. (a) external aspect; (b) umbonal aspect. Circ. nat. size.
- Fig. 17.—*G. convexa*, Tate sp. Kalimnan. Muddy Creek, upper beds. Plesiotype. Tate Coll., Adelaide University. Umbonal aspect of shell on left of Tate's figured specimen (holotype). Circ. nat. size.
- Fig. 18.—*G. convexa*, Tate sp. Kalimnan. Muddy Creek, upper beds. Plesiotype. Tate Coll., Adelaide University. Internal aspect of shell on right of Tate's figured specimen. Circ. nat. size.
- Fig. 19.—*G. convexa*, Tate sp. Kalimnan. Muddy Creek, upper beds. Plesiotype. Tate Coll., Adelaide University. Neanic example, below Tate's figured specimen. Circ. nat. size.
- Fig. 20.—*G. convexa*, Tate sp. Kalimnan. MacDonald's, Muddy Creek. Plesiotype. Nat. Mus.; coll. and pres. F. Chapman. Neanic example, figured by Chapman and Gabriel as *G. maccayi*. Nat. size. [12467.]

PLATE III.

- Fig. 21.—*Glycymeris subadians*, Tate. Kalimnan. Marino, near Hallett's Cove. Plesiotype. Private coll. of Dr. H. Basedow, Adelaide. Circ. nat. size.
- Fig. 22.—*G. subadians*, Tate. Kalimnan. Hallett's Cove. Plesiotype. Dennant Coll., Nat. Mus. Circ. nat. size. [13331.]
- Fig. 23.—*G. halli*, Pritchard. Kalimnan. MacDonald's, Muddy Creek. Plesiotype. Nat. Mus. Coll.; pres. R. Hughan. Slightly reduced. [7842.]
- Fig. 24.—*G. decurrens*, sp. nov. Kalimnan. Forsyth's, Grange Burn. Holotype. Nat. Mus. Coll.; pres. F. A. Singleton. (a) exterior; (b) interior. Circ. nat. size. [13332.]
- Fig. 25.—*G. decurrens*, sp. nov. Kalimnan. Forsyth's, Grange Burn. Paratype. Nat. Mus.; coll. and pres. F. Chapman. (a) exterior; (b) interior. Slightly reduced. [13333.]
- Fig. 26.—*G. planiuscula*, sp. nov. Werrikoonian. Limestone Creek, Glenelg River. Holotype. Dennant Coll., Nat. Mus. Slightly enlarged. [13334.]
- Fig. 27.—*G. planiuscula*, sp. nov. Werrikoonian. Limestone Creek, Glenelg River. Paratype. Dennant Coll., Nat. Mus. Circ. nat. size. [13335.]

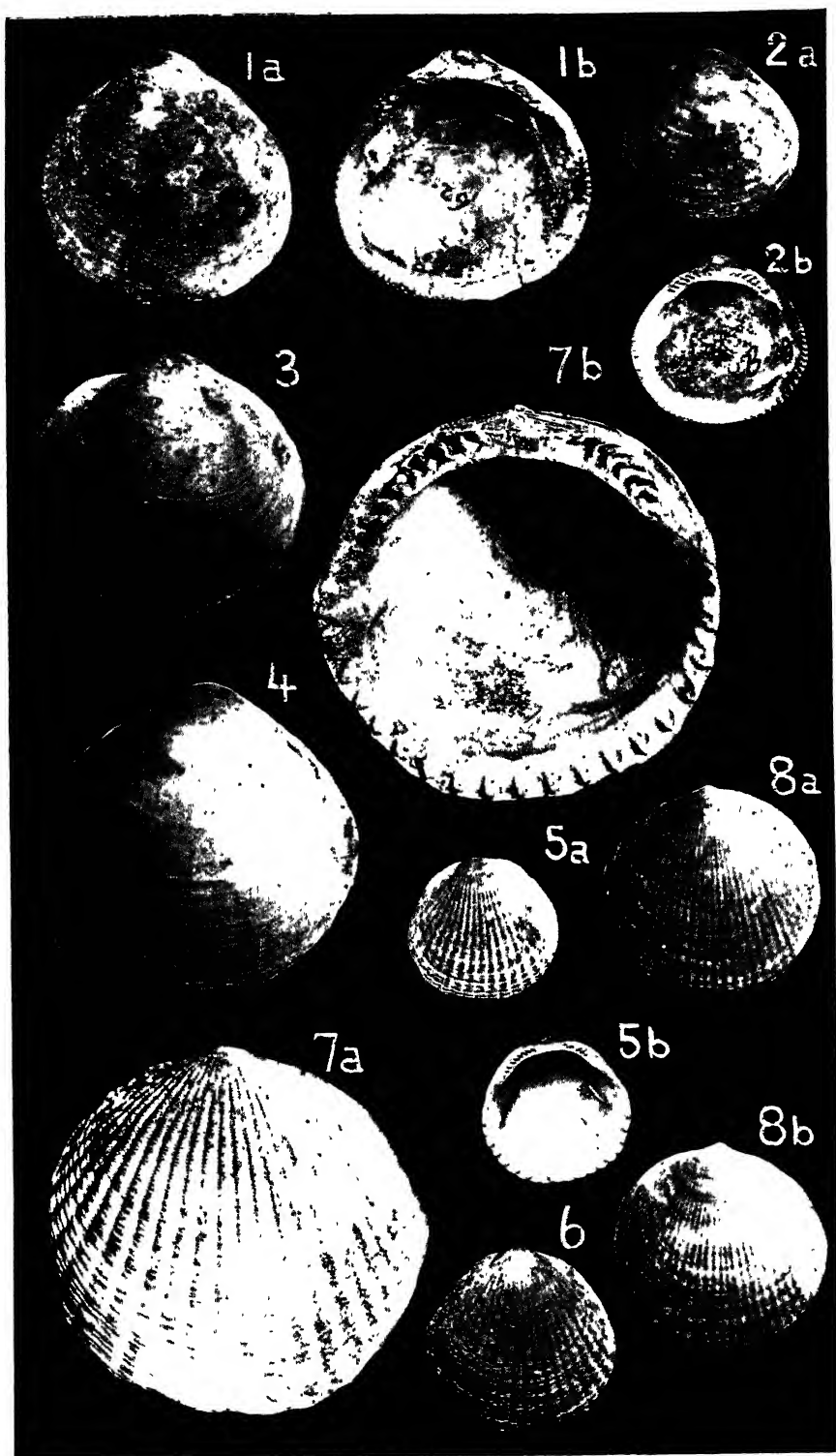
- Fig. 28.—*G. planiuscula*, sp. nov. Kalimnan. Forsyth's, Grange Burn. Paratype. Nat. Mus.; coll. and pres. F. Chapman. Circ. nat. size. [13336.]
- Fig. 29.—*G. flabellata*, T. Woods sp. Recent. N.E. Tasmania. Neotype. Nat. Mus. Coll. (a) exterior; (b) interior. Slightly reduced. [36805.]
- Fig. 30.—*G. flabellata*, T. Woods sp. Werrikooian. Limestone Creek, Glenelg River. Plesiotype. Dennant Coll., Nat. Mus. Circ. nat. size. [13337.]
- Fig. 31.—*G. striatularis*, Lamarck sp. Werrikooian. Limestone Creek, Glenelg River. Plesiotype. Dennant Coll., Nat. Mus. Circ. nat. size. [13338.]
- Fig. 32.—*G. australis*, Quoy and Gaimard sp., var. *gigantea*, Chapman. Werrikooian. Vivonne Bay, Kangaroo Is. Holotype of variety. Nat. Mus.; coll. Dr. A. Wade. Slightly reduced. [13339.]

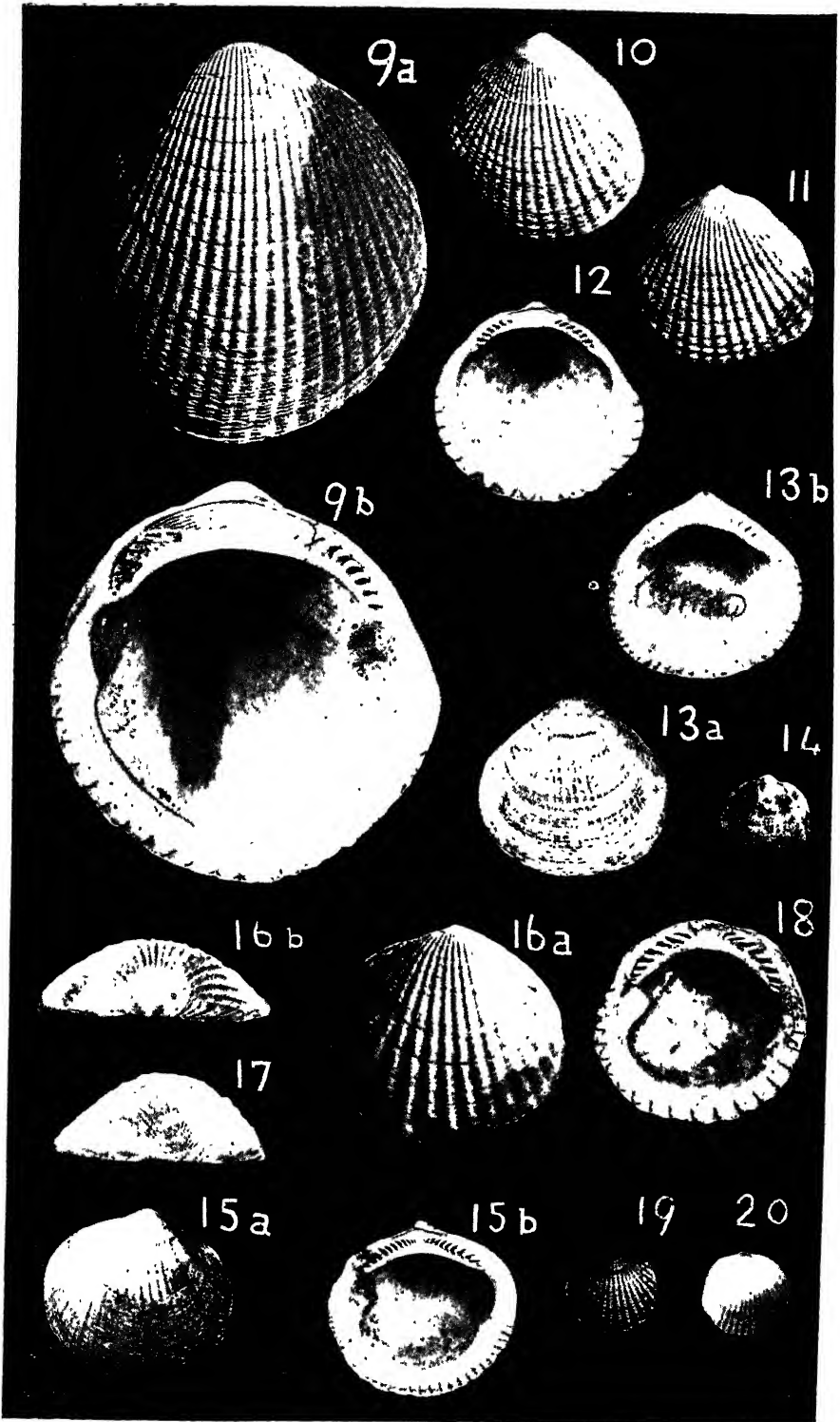
PLATE IV.

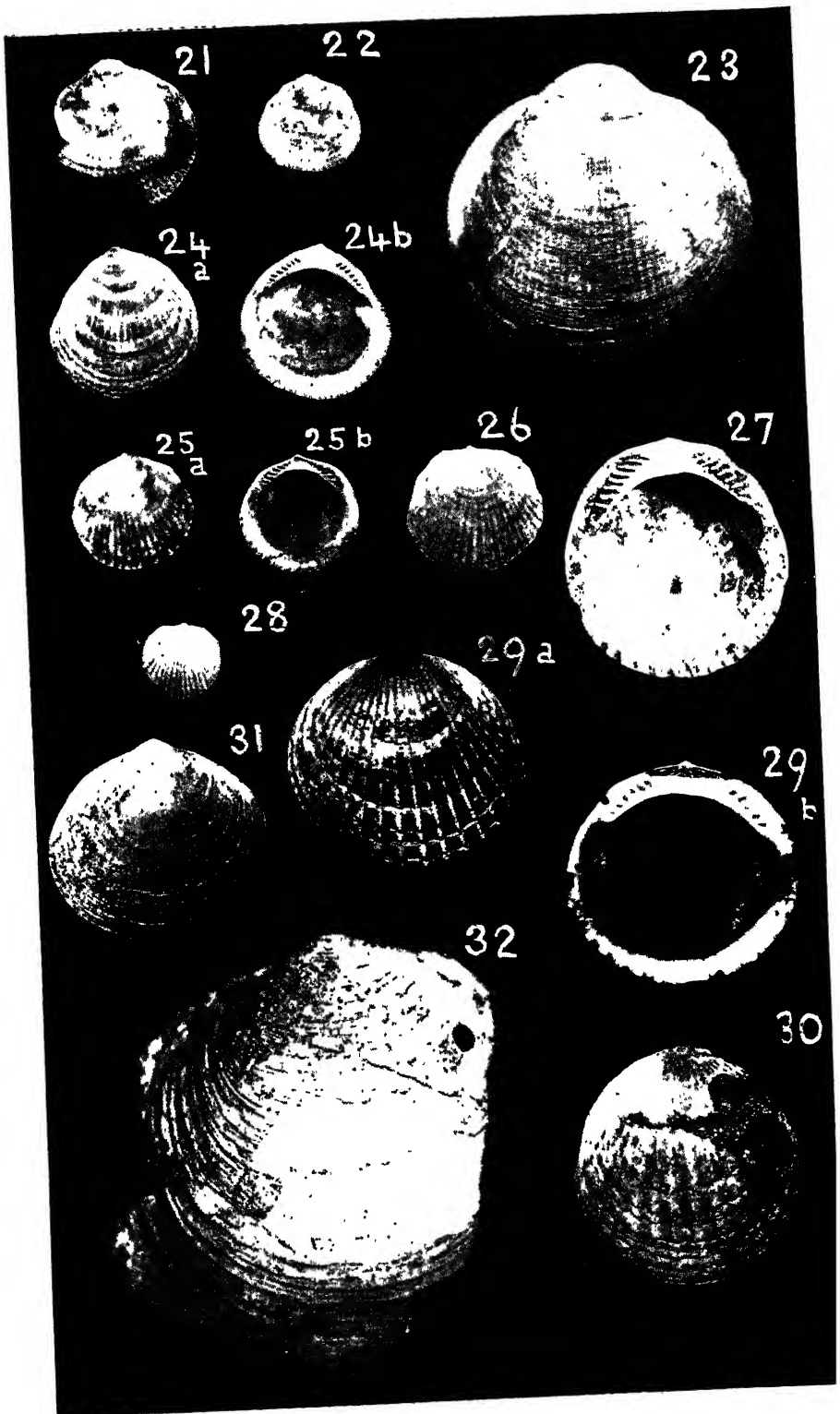
Umbono-Ventral Profiles drawn to Natural Size.

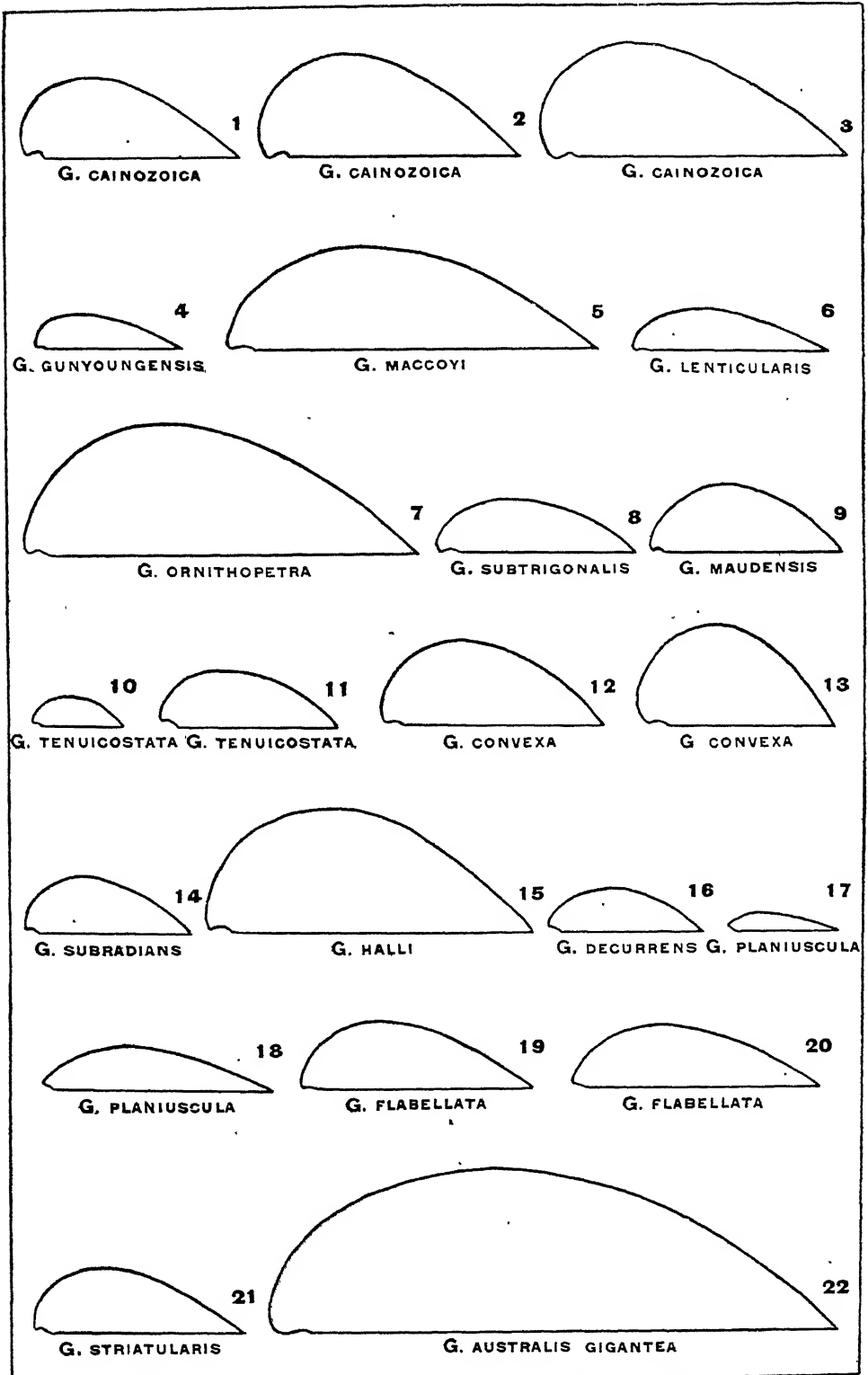
- Fig. 1.—*Glycymeris caenozoica*, T. Woods sp. Holotype. (Pl. I., Fig. 1.)
- Fig. 2.—*G. caenozoica*, T. Woods sp. Plesiotype. (Pl. I., Fig. 3.)
- Fig. 3.—*G. caenozoica*, T. Woods sp. Plesiotype. (Pl. I., Fig. 4.)
- Fig. 4.—*G. gunyoungensis*, sp. nov. Holotype. (Pl. I., Fig. 5.)
- Fig. 5.—*G. maccoyi*, Johnston sp. Neotype. (Pl. I., Fig. 7.)
- Fig. 6.—*G. lenticularis*, Tate sp. Cotype. (Pl. I., Fig. 8.)
- Fig. 7.—*G. ornithopetra*, sp. nov. Holotype. (Pl. II., Fig. 9.)
- Fig. 8.—*G. subtrigonalis*, Tate sp. Holotype. (Pl. II., Fig. 10.)
- Fig. 9.—*G. maudensis*, sp. nov. Holotype. (Pl. II., Fig. 13.)
- Fig. 10.—*G. tenuicostata*, Reeve sp. Plesiotype. (Pl. II., Fig. 14.)
- Fig. 11.—*G. tenuicostata*, Reeve sp. Plesiotype. (Pl. II., Fig. 15.)
- Fig. 12.—*G. convexa*, Tate sp. Holotype. (Pl. II., Fig. 16.)
- Fig. 13.—*G. convexa*, Tate sp. Plesiotype. (Pl. II., Fig. 17.)
- Fig. 14.—*G. subadians*, Tate. Plesiotype. (Pl. III., Fig. 21.)
- Fig. 15.—*G. halli*, Pritchard. Plesiotype. (Pl. III., Fig. 23.)
- Fig. 16.—*G. decurrens*, sp. nov. Holotype. (Pl. III., Fig. 24.)
- Fig. 17.—*G. planiuscula*, sp. nov. Holotype. (Pl. III., Fig. 26.)
- Fig. 18.—*G. planiuscula*, sp. nov. Paratype. (Pl. III., Fig. 27.)
- Fig. 19.—*G. flabellata*, T. Woods sp. Neotype. (Pl. III., Fig. 29.)
- Fig. 20.—*G. flabellata*, T. Woods sp. Plesiotype. (Pl. III., Fig. 30.)
- Fig. 21.—*G. striatularis*, Lamarck sp. Plesiotype. (Pl. III., Fig. 31.)
- Fig. 22.—*G. australis*, Quoy and Gaimard sp., var. *gigantea*, Chapman. Holotype of variety. (Pl. III., Fig. 32.)

ADDENDUM.—Since the above was written, Iredale (Proc. Linn. Soc. N.S. Wales. Vol. XLIX., Pt. III., 1924, p. 187) has advised the rejection of *P. australis*, Q. and G., on the ground of preoccupation by Morton (Synops. Org. Remains Cret. Group, U.S., 1834, p. 64), whose name he suspects to have appeared earlier in the year than that of Quoy and Gaimard. Were the evidence not more definite than this, we should hesitate to abandon this well-known name for the Australian shell, but examination of the dates of publication of the various sections of the Zoology of the "Voyage d'Astrolabe" discloses an interesting problem. The Atlas in which our shell is figured bears the date 1833, but the name given is in a vernacular form (*Pétoncle austral*) of Quoy and Gaimard's intentioned name of the species. The conchological section constitutes Vol. III. of the Zoology, and appeared in two parts; the first (pp. 1-368) in 1834, and the second (pp. 359-954), which includes the diagnosis of our species, in 1835. If the latter date be taken, then Morton's name has clear priority, but if the readily identifiable figures are accepted, despite the form of the accompanying legend, then the reverse is the case; we therefore leave the matter open. F.C. and F.A.S., 9.3.25.









F.C. et F.A.S. ad nat. del.

Umbono-Ventral Profiles in *Glycymeris*.

ART. III.—*The Distribution of Anopheline Mosquitoes in the Australian Region, with Notes on some Culicine Species.*

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(Communicated by J. A. Kershaw, F.E.S.).

(With Plates V.-IX.)

[Read 13th March, 1924.]

The tribe *Anophelini* comprises one of the two principal divisions of the sub-family *Culicinae*, and is represented throughout the tropical and temperate regions of the world by numerous species, some, but not all, of which are capable of transmitting malaria. A knowledge of the distribution and habits of the various species existing in Australia and New Guinea is, therefore, of practical value in, if not an essential preliminary to, effective anti-malaria measures. A study of the literature on the subject and a personal investigation of conditions in the field, as well as a critical examination of a large number of specimens from various localities, convince the writer that our knowledge is totally inadequate to a thorough scientific study of the distribution of the disease, its disseminators and its eradication or reduction.

It is 26 years since Grassi discovered that malaria is conveyed from infected to non-infected persons by anopheline mosquitoes, yet the species of carrier or carriers is still unknown in Australia. Maplestone (1923) says: "The statement by Harrison (1922) is an accurate summary of the present state of our knowledge in this respect, when he says that there is evidence that the local *Anopheles* are capable of acting as intermediate hosts for the malaria parasite." Harrison's statement still summarises the position. *Anopheles annulipes* Walker is generally hypothesized for Australia, but Maplestone considers that *A. bancrofti* Giles has more to do with malaria than has hitherto been supposed. References to *Anopheles* in North-West Australia are few and, for the reason given below, indefinite, notwithstanding the fact that in certain localities malaria is endemic. The breeding places of *A. annulipes* have been described in some detail (Hill, 1922), but as a result of more recent research this information must now be regarded as applying more especially to related forms of doubtful status.

In Papua, also, where malaria is endemic, the carrier or carriers is undetermined and anti-anopheles measures have been confined to the more obvious surface accumulations of water in ignorance of the fact that native canoes and seepage are sources

of an abundant supply of potential, if not actual, carriers of two species, one of which has not hitherto been recorded from the Australian region. In New Britain, where Dr. G. M. Heydon has definitely implicated two of the three known species, knowledge of the relationship of *Anopheles* to malaria and of the breeding habits of the carriers is far more advanced than it is in Australia or Papua.

The Tribe *Culicini*, which includes the greater part of the mosquito fauna of the region, is of less importance than the Tribe *Anophelini*, but, as many of its included and little known species cannot be regarded otherwise than as potential carriers of parasitic diseases in man, a much greater knowledge than we now possess of their habits and early stages is very desirable.

In preparing this contribution to the literature on the subject the writer has followed the classification and nomenclature adopted by Edwards, whose recent paper (1924) provides students with the first authoritative list of the Australian species, with the synonyms under which many of them have remained obscured.

Anopheles of Australia.

Eight species of *Anopheles* have been recorded from Australia, namely:—*A. corethroides* Theo. (S. Queensland), *A. atratipes* Skuse (S. Queensland and New South Wales), *A. stigmaticus* Skuse (New South Wales), *A. bancrofti* Giles (Queensland and Northern Territory), *A. annulipes* Walker (Tasmania and Australia generally), *A. musivus* Skuse (New South Wales), *A. mastersi* Skuse (New South Wales), and *A. amictus* Edwards (N. Queensland and N. Territory). *A. corethroides* is synonymous with *A. stigmaticus*, while the latter and *A. atratipes*, two well-defined and rare species, are negligible as disseminators of malaria, and need not be referred to again in this paper.

A. bancrofti is considered by Edwards (1924) to be almost certainly specifically distinct from *A. barbirostris* v. d. Wulp. In the absence of males from the Oriental region the writer has been unable to make a comparison between the New Guinea and Indian forms, but it can be stated definitely that no distinction exists in either sex between specimens from Queensland, Northern Territory, Banks Is. (Torres Strait), Madang (New Guinea), and Admiralty Islands. The most obvious distinction in the females is stated by Edwards to be in the presence of numerous more or less scattered pale scales on the femora and tibiae of *A. bancrofti*. These are certainly present in all the Australian and New Guinea specimens the writer has examined, as well as in an Indian specimen determined by Christophers. Theobald, Christophers and recent Dutch writers, on the other hand, refer New Guinea specimens to *A. barbirostris*, a proved carrier of malaria in various parts of the Malay Archipelago.

The remaining four species, namely, *A. annulipes*, *A. musivus*, *A. mastersi* and *A. amictus*, are all closely allied to each other, and

constitute a well-defined and widely distributed group (Sub-genus *Myzomyia*), characterised by boldly marked wings and spotted legs. The validity of three of the four species has been questioned by different writers. The group is an important one and, since it probably includes the principal carrier or carriers of malaria in Australia, it is desirable that the status of these related forms, and several others as yet undescribed, should be definitely determined. Some may be carriers of malaria, others not. A satisfactory definition of these species, varieties or races—which ever they may prove to be—and their geographical distribution might offer a more acceptable explanation of the remarkable distribution of malaria in Australia than has been advanced hitherto. With the object of throwing some light on the subject the writer examined all the available material (over 400 adults) collected by him since the early part of 1911 in various localities, and, in addition, several small collections from South-West Australia, South Queensland and Tasmania. The results, so far as the above-mentioned species are concerned, are not conclusive, but they show that two described and one undescribed form from North Australia must now be added to the list of possible carriers.

The differences between some of these forms are hardly appreciable; in others they are sufficiently well marked to appear to warrant their recognition, for the time being at any rate, as distinct varieties, if not species. Difficulties arise, however, in deciding the dividing line owing to the occurrence of intermediates. The following observations refer to females only, unless the contrary is stated.

A comparison between two specimens from Tasmania, 54 from Victoria, 28 from South-West Australia, and 90 from South Queensland shows that each series contains individuals of both sexes identical with each other in every respect. In one unimportant detail (the absence of basal bands on the tarsal joints) most of them differ from the typical *annulipes* from Tasmania, but there can be no doubt that they are referable to this species. The South-West Australian and Queensland series contain, also, several variations from the above, differing only in the presence or absence of certain bands on the legs and scales on some of the body segments. Specimens from New South Wales have not been examined, but there is no doubt in the writer's mind that both of the described species from that locality (*musivus* and *mastersi*) are identical.

Townsville (N.Q.) specimens of both sexes can be separated readily into three groups on the colour of the proboscis and legs, and on the nature of the scales on the abdomen. Some individuals in one group ("A") cannot be distinguished from specimens from southern Australia, and are unhesitatingly referred to Walker's species (*annulipes*); the other two ("B" and "C") contain specimens of approximately the same size, but more yellow in colour. Slight variations occur in each group,

some of which show evidence of close relationship between all three. Breeding experiments designed to determine the relationship (if any) were undertaken successfully, but, unfortunately, only the males are now available for examination. This shows clearly that typical female examples of each of these three groups do not always produce males which can be correctly assigned to the groups to which their respective female parents belonged without a knowledge of their history. Examples of all three groups have been reared repeatedly from larvae collected in the same puddles—generally hoof-holes near swamps.

The characters and distribution of these three groups are:—

"A" *A. annulipes* Walk., *A. mastersi* Skuse, *A. musivus* Skuse. (Fig. 1 a-f). Proboscis with apical half testaceous, with or without dark scales near the labellum, these rarely extending over the entire apical 1/5, proboscis sometimes entirely dark scaled (three specimens captured in Melbourne in mid-winter); tarsi with apical bands, rarely with basal bands on joints 2-4 of fore-legs; spots on femora and tibiae variable in size; abdomen with scanty long pale scales on segments 2-7, increasing in number progressively from the second, 8th segment and cerci more or less covered with white scales, or frequently with only two or three pale scales on segments 2-7, or, rarely, with more numerous scales (but noticeably less than in "B"), mostly pale yellow in colour. Distribution: Tasmania, Southern Australia generally, Queensland, (Brisbane, Townsville, Cairns), Central Australia (Charlotte Waters, Alice Springs).

"B" *A. amictus* Edw. (Fig. 2 a-f). Proboscis entirely dark; tarsi with apical bands only, leg spots variable; abdomen rather densely clothed with short broad, mostly yellow, scales, with a patch of dark (lead) ones in the middle of segments 4-6, or on the greater part of segments 2-6, or, occasionally, reduced to a few on each of the median segments. There can be no doubt that this is the species described by Edwards; the description of the wings, however, does not agree, since the first longitudinal vein almost invariably bears long spots, a character of no importance because hardly two individuals are marked alike, and differences often occur in wings of the same insect. Distribution: North Queensland (Townsville, Palm Island), Northern Territory (Darwin).

"C" *A. (?) amictus* Edw. (Fig. 3 a-f). Proboscis entirely dark; tarsi apically and basally banded; abdomen rather densely clothed with golden scales rather longer and narrower than those in *amictus*, very rarely a few dark scales on middle of segments 4-6. Several examples (from Darwin) have much wider tarsal bands, 4th tarsi entirely white and abdomen as in typical *amictus*.

The egg measures 0.530 mm. in length, and has a maximum width (exclusive of the floats) of 0.215; otherwise it is similar to that of *A. punctulatus* var. *moluccensis* (Swell.), which is only 0.480 mm. in length.

Of 100 females from Townsville 25 are referred to group "B" (*A. amictus*); 1 to group "C," and 42 to group "A" (*A. annulipes*); but among the 42 are 7 specimens that are known definitely to be the progeny of typical females of *amictus*, and 5 of typical females of group "C."

The male genitalia have not been compared.

In addition to the forms referred to above, *A. punctulatus* var. *moluccensis* (Swell.) occurs commonly in various localities between Port Darwin and the Katherine River, Northern Territory, whilst a single example (female) from Borroloola, N.T., is identical with *A. punctulatus* Don. Both have been demonstrated as carriers of malaria in New Britain.

A general survey of the material referred to above shows that the southern specimens of *A. annulipes* are usually larger and more vividly coloured (black and white) than those from Northern localities, but the South Queensland and some of the Northern Territory specimens occupy an intermediate position as regards colour, and are of the maximum size.

For practical purposes, and especially to facilitate recording infection experiments with malaria, it may be desirable to distinguish by varietal names some of the above, but it appears to be otherwise undesirable to burden the literature with additional names until decisive experiments have been carried out.

The examination of numerous larvae from Townsville, New Guinea, and New Britain show that they vary considerably, and cannot be relied upon to differentiate the closely allied forms found there.

Anopheles of New Guinea, New Britain and adjacent Islands.

The following species or varieties of *Anopheles* have been recorded from New Guinea, New Britain and adjacent islands:—

Bironella gracilis Theobald (North-West New Guinea).

Stethomyia aitkeni var. *papuae* Swellengrebel (North-West New Guinea).

Anopheles barbirostris v. d. Wulp (New Guinea).

Anopheles umbrosus Theobald (New Guinea).

Anopheles punctulatus Donitz (New Guinea and New Britain).

Nyssorhynchus annulipes var. *moluccensis* Swell. (New Guinea).

Nyssorhynchus annulipes Walker (Papua).

An examination of the specimens recorded from Papua by Taylor as *A. annulipes* shows them to be referable to *moluccensis*.

Christophers' (Trans. 4th Congr. Far Eastern Assn. Trop. Med.) record of *A. umbrosus* from New Guinea and Australia probably refers to *A. bancrofti* Giles.

Bironella gracilis (Fig. 4 a-e) occurs also in New Britain, where the larvae were found abundantly in a small running mountain stream (tributary of the Nambung River) in the Beining District, by Heydon and the writer in 1922. The above figures supplement those of Brug and de Rook (1922). The outer clypeal hairs could not be detected in any of the New Britain specimens; those figured (detached) are copied from the Dutch authors' work.

A. punctulatus (Fig. 5 a-e) occurs in New Britain, Papua (Moresby and Mekeo Districts), Samarai and Woodlark Island. In the first-mentioned locality, where the most systematic collecting has been done, it has been reared only from temporary rain pools, roadside puddles, and such depressions as are formed by the natives and stock on muddy tracks, but it has been reared by the writer also from seepage and running grass-covered plantation drains in Samarai, and from beached native canoes near Moresby. It occurs at moderately high elevations (? 1800 feet) in New Britain (Toma and Beining Mts.).

N. annulipes var. *moluccensis* (Fig. 6 a-d) is regarded by Edwards as synonymous with *punctulatus*. It is the predominant form in New Britain and Papua (Moresby and Mekeo Districts), and the only form of *Myzomyia* the writer has seen from Madang, Admiralty Group, Solomon Group and New Ireland. It does not occur in Samarai, as far as is known. In New Britain it breeds near the sea beaches in grass-grown drains, wells and brackish swamps, where neither Heydon nor the writer have ever found Donitz's species. An examination of a long series from Australia, New Guinea and New Britain shows that *moluccensis* is more valuable in adult and larval stages than is indicated in the description and figures. The following are some of the variations noted in the adults:—2nd joint of palpi with white ring at apex, generally slightly longer than 3rd and 4th together, but often equal; labellum rarely black; abdominal tergites 1-7 without scales, or 1-3 without scales and a few on 4-7, or a few on 2-7; sternites 1-7 generally without scales, sometimes a few white ones on 8th; wing markings very variable; legs often without large spots forming incomplete rings, commonly as in Fig. 6 c and d; tarsi rarely entirely dark except for a few spots near middle of 1st hind tarsi; 4th and 5th hind tarsi commonly entirely dark. The eggs, larvae, pupae and males are apparently indistinguishable from those of *punctulatus*. The adult female *punctulatus* is distinguished by the proboscis, which is pale on the apical half, with or without a dark scaled subapical area on the ventral surface. The legs are generally much paler than those of *moluccensis*, but they are very variable and sometimes cannot be distinguished from those of the commoner form. The palpi generally have a broad white zone near the apex of the second segment, but this character is not constant. The relative length of the second palpal joint to the third and fourth is alike in the two forms.

The occurrence of *A. subpictus* Grassi¹ in Papua is recorded here for the first time from specimens bred by the writer from beached native canoes near Moresby, and from adults captured in various places in the Mekeo District. There is the strongest circumstantial evidence that it is the species responsible for an infection of benign tertian malaria contracted by the writer, and it is possibly an important factor in the transmission of the disease in that portion of the possession, where canoes have not been suspected hitherto of affording a breeding place for *Anopheles*. The larvae and pupae, which were very numerous in several canoes within easy flight of a large native village and the official residential area of Moresby, were associated with a few *A. punctulatus* and numerous *Culex sitiens* Wied. The female is readily distinguished from *punctulatus* by the following characters:—Absence of spots on the legs; 2nd joint of palpi noticeably longer than 3rd and 4th together, and entirely dark, excepting for a narrow white ring or dorsal spot at its apex; 3rd joint with a wide apical ring, and 5th entirely white.

There remains to be mentioned an unidentified species represented by larvae (Fig. 8) found in a foul pool in felled jungle in the Beining District of New Britain. It is evidently distinct from any of the species mentioned in this paper.

Notes on Culicine Mosquitoes.

Megarhinus (Toxorhynchites) inornatus Walker.

Proc. Linn. Soc., VIII., p. 102 (1865).

(Pl. VI., Fig. 9, a-d.)

This species breeds in rot-holes in trees and in tins, bottles, etc., in secluded places. The larvae are predaceous on other species.

Localities: New Britain (Rabaul and Beining Districts); Papua (Samarai).

Uranotaenia nigerrima Taylor.

Trans. Ent. Soc. 1914, p. 203 (1914).

Adults were captured in June and July in a jungle-covered ravine and on the undercut sides of wells in the vicinity of the beach.

Localities: New Britain (Rabaul and Beining Districts); Papua (Mekeo District).

Uranotaenia ? *argyrotarsis* Leicester.

Several specimens were found in association with *U. nigerrima* in Rabaul. It is easily distinguished, even on the wing, from

1. Identified by Mr. Edwards from specimens forwarded to him as *A. rossi* Giles.

other local species by its white tarsi and silvery white patches of scales on the dorsum of the abdomen. Mr. Edwards, to whom specimens were referred, considers it to be too closely allied to Leicester's species to be described as new until males are available for examination.

Localities: New Britain (Rabaul); New Ireland (Kaewieng).

Uranotaenia atra Theobald.

Ann. Mus. Nat. Hung. III., p. 114 (1905).

Adults were captured on the undercut sides of an open native well.

Locality: Papua (Mekeo District).

Hodgesia spoliata Edwards.

Bull. Ent. Res. XIV. p. 8 (1923).

This species occurs, with *H. atra*, in dense jungles, and in the mangroves fringing the banks of tidal streams and estuaries. It bites freely at all times of the day.

Locality: Papua (Mekeo and Moresby Districts).

Hodgesia cairnsensis Taylor.

Proc. Linn. Soc. N.S.W., XLIII., p. 842 (1919).

Occurs in dense scrub and in the mangroves, where it is more plentiful and more troublesome than the preceding species.

Localities: New Britain (Rabaul); New Ireland (Kaewieng); Papua (Moresby District).

Hodgesia quasisanguinea Leicester.

Cul. of Malaya, p. 230 (1908).

The above, or a very closely allied species, occurs in the vicinity of Rabaul.

Locality: New Britain (Rabaul); Australia.

Rachionotomysia quasiornata Taylor.

Proc. Linn. Soc. N.S.W., XL., p. 177 (1915).

(Pl. VI., Fig. 10).

Although few specimens have been taken it is probably a common species in suitable localities, i.e., in dense jungle. It does not enter houses, and appears to be entirely diurnal and sylvan in its habits. Like many other sylvan species it is timorous, and rarely attempts to bite unless one remains almost motionless—a difficult matter in the presence of more numerous and more voracious species. Larvae were taken in rot-holes in trees in the first-mentioned locality.

Localities: New Britain (Rabaul, Toma, Beinging District); Papua (Woodlark Is., Moresby and Mekeo Districts).

Rachionotomyia filipes Walker.

Proc. Linn. Soc. V., p. 229 (1861); Taylor, Trans. Ent. Soc. 1914, p. 190 (1914), (*Stegomyia atra*).

The character by which Edwards (1924) distinguishes *atra* from this species is not constant in several specimens from Papua and New Ireland, which have the apical lateral white spots on the abdominal tergites quite as well marked as in the Northern Territory examples; the writer regards Taylor's species, therefore, as synonymous with Walker's.

Taeniorhynchus (*Coquillettidia*) *giblini* Taylor.

Trans. Ent. Soc. 1914, p. 198 (1914), (*Pseudotaeniorhynchus conopas* var. *giblini*).

Localities: Papua (Mekeo District); New Guinea (Madang).

Taeniorhynchus (*Coquillettidia*) *brevicellulus* Theobald.

Mon. Cul. 11, p. 212 (1901).

Examples (females) collected in the Mekeo District in cane-grass flats, in dense jungle, and in open scrub country agree with the less extensively purple scaled specimens in a series from New Ireland, the darkest forms of which have been identified recently as above, and, also, with the darkest forms of *T. xanthogaster* Edwards from Northern Territory. The two species appear to be impossible to separate in the absence of males.

Locality: New Ireland (Kaewieng).

Taeniorhynchus (*Mansonioides*) *uniformis* Theobald.

Mon. Cul. 11, p. 180 (1901) (*Panophiles*).

This is a very common species in Papua, especially in the Mekeo District, where, in July, it was by far the most annoying species encountered. In most of the native villages in this district mosquito-nets (made of hessian) were in evidence in many of the huts, and, upon examination, were invariably found to contain numerous engorged specimens. It is a most persistent biter, and is active throughout the day and night. The greatest numbers were found in the vicinity of weedy freshwater swamps and backwaters, but it was frequently observed in the mangroves in association with *Aedes* (*Ochlerotatus*) *vigilax* and *Aedes* (*Skusea*) *funereus*.

Localities: New Guinea (Madang); Papua (Moresby and Mekeo Districts); New Ireland (Kaewieng); Admiralty Group.

Taeniorhynchus (*Mansonioides*) *annulipes* Walker.

Proc. Linn. Soc., 1, p. 5 (1857), (*Culex*).

Specimens collected in the Mekeo District, in association with *T. uniformis* and *T. papuensis*, agree with others from New Ireland (Kaewieng), New Guinea (Madang) and Queensland.

The writer referred the latter inadvertently to *septemguttata* (*septempunctata*, a doubtful synonym of *annulipes*, was intended).

Taeniorhynchus (*Mansonioides*) *papucensis* Taylor.

Trans. Ent. Soc. 1914, p. 200 (1914).

This species has been known hitherto from the type series only; nevertheless it is common in cane-grass swamps and adjacent jungle, where it is hardly less annoying, though less abundant, than *uniformis*.

Locality: Papua (Mekeo District).

Mucidus alternans Westwood,

Ann. Soc. Ent. France, IV., p. 681 (1835).

(Pl. VI., Fig. 11 a-d.)

The figures are from North Queensland specimens. The anal papillae are variable in length, but they are generally about as long as the segment itself or half as long as the four simple hairs at its apex in specimens bred from fresh or only slightly brackish swamps.

Armigeres lacuum Edwards.

Bull. Ent. Res. XIII., p. 97 (1922).

(Pl. VI., Fig. 12 a-e.)

This is a very common species, the early stages of which are found, sometimes in great numbers, in cut-off bamboos, rot-holes in trees, and similar places. The adults are sluggish in their habits, but are capable of causing much annoyance. In the shelter of dense jungle they bite throughout the day, but do not venture from such cover until evening, when they are commonly found in dwellings and outhouses.

Localities: New Britain (coastal and mountain districts); New Ireland; New Guinea (Madang); Admiralty Group.

Armigeres ? *breinli* Taylor.

Trans. Ent. Soc. 1914, p. 186 (1914) (*Neosquamomyia*).

Several specimens (female) were reared from larvae and pupae collected in a rot-hole in a tree; others were captured whilst biting in the jungle. Taylor, as recorded by Edwards (1924), has confused two species under this name.

Locality: Papua (Mekeo District).

Aedes (*Stegomyia*) *variegatus* Doleschall.

Nat. Tijds. Ned. Ind., XVII., p. 77 (1858). (*Culex*).

(Pl. VII., Fig. 13 a-d.)

This mosquito is widely distributed, and very abundant in many localities. It is found commonly in houses and native huts, and

almost as commonly in the jungle. It appears to be more markedly diurnal in its feeding habits than is *argenteus*. The principal breeding places are in half cocoanuts, rot-holes in trees, wells in native gardens and villages and in beached canoes.

Localities: New Britain (Rabaul and Beining Districts); New Ireland (Kaewieng); Admiralty Group; Papua (Samarai, Kaile, Moresby, Boira, Yule Is., Waima); New Guinea (Madang).

Aedes (Stegomyia) argenteus Poiret.

(*Stegomyia fasciata*)

Locality: New Britain; New Ireland; Solomon Group.

Aedes (Stegomyia) albolineatus Theobald.

(Pl. VII., Fig. 14.)

Specimens received from Drs. Heydon and Wallace have been identified as above by Mr. Edwards.

Localities: Russell Group; New Ireland (Kaewieng).

Aedes (Stegomyia) albopictus Skuse.

Ind. Mus. Notes III., p. 5 (1895) (*Culex*).

Localities: Papua (Mekeo and Moresby Districts); Islands of Torres Strait; Australia (Darwin).

Aedes (Aediomorphus) alboscuteclatus Theobald.

Ann. Mus. Nat. Hung. III., p. 80 (1905) (*Lepidotomyia*).

Localities: Papua (Mekeo District and Woodlark Is.).

Aedes (Ochlerotatus) vittiger Skuse.

Proc. Linn. Soc. N.S.W. (2) III., p. 1728 (1889) (*Culex*).

(Pl. VII., Fig. 15 a-g.)

Localities: Queensland; New South Wales.

Aedes (Ochlerotatus) vandema Strickland.

Entom. XLIV., p. 202 (1911) (*Culicada*).

This appears to be a rather common species in the vicinity of the foothills of the Dandenong Ranges, Vic., where it is associated with *Aedes (O.) camptorhynchus* (Thoms.) and *Theobaldia frenchi* (Theo.).

Aedes (Ochlerotatus) vigilax Skuse.

Proc. Linn. Soc. N.S.W. (2) III., p. 1731 (1889) (*Culex*).

(Pl. VII., Fig. 16 a-c.)

The fact that this species occasionally breeds in fresh water has been recorded in an earlier paper (Hill, 1922); such larvae have longer and narrower anal papillae than those bred under more normal conditions. A similar change takes place in *Mucidus*

alternans, but apparently not in *Culex sitiens*, both of which breed in fresh or salt water.

Localities: Australia; Papua.

Aedes (Finlaya) kocki Dönitz.

Insekten Borse, V., p. 38 (1901) (*Culex*).

Although generally found as a sylvan species, it frequently enters houses. Larvae were taken in half cocoanuts on many occasions. The pale markings on the wings and legs are generally tinged with yellow, but are often pure white.

Localities: New Britain; New Ireland; Woodlark Island; Papua (Waima and Yule Island).

Aedes (Finlaya) milsoni Taylor.

Proc. Linn. Soc. N.S.W. XL., p. 179 (1915) (*Culicada*).

This species has been reared from larvae and pupae taken in a rot-hole in a tree, Gembrook District, Victoria (G.F.H., May, 1924).

Aedes (Finlaya) notoscriptus Skuse.

Proc. Linn. Soc. N.S.W. (2), III., p. 1738 (1889) (*Culex*).

(Pl. VII., Fig. 17.)

Localities: New Britain; New Ireland; Admiralty Group.

Aedes (Finlaya) quasirubrithorax Theobald.

Mon. Cul. V., p. 348 (1908) (*Culex*).

(Pl. VIII., Fig. 18 a-d.)

The figures are drawn from specimens found in a rot-hole in a tree.

Locality: Queensland (Townsville).

Aedes (Macleaya) tremula Theobald.

Entom. XXXVI., p. 154 (1903).

(Pl. VIII., Fig. 19 a-c.)

The figures are drawn from Queensland specimens.

Aedes (Pseudoskusea ?) culciformis Theobald.

Ann. Mus. Nat. Hung., III., p. 77 (1905) (*Skusea*).

Localities: New Britain; New Ireland; New Guinea; Papua (Mekeo District).

Aedes (Pseudoskusea) concolor Taylor.

Trans. Ent. Soc. 1913, p. 1700 (1914) (*Caenoccephalus*).

Locality: Victoria (Coode Is.).

Aedes (Aedes) funereus Theobald.Mon., Cul. III., p. 292 (1903) (*Skusea*).

(Pl. VIII., Fig. 20.)

A common and troublesome species in many coastal localities, especially in the vicinity of mangroves and adjacent scrub.

Localities: New Britain; New Ireland; New Guinea; Papua.

Aedes (Aedes) funereus, var. *rnatus* Theobald.Ann. Mus. Nat. Hung. III., p. 79 (1905 (*Skusea*)).

One of the commonest and most troublesome jungle-frequenting species in both coastal and inland localities. It is diurnal and nocturnal in its feeding habits, but does not enter houses. It breeds in grass-covered plantation drains.

Localities: New Britain; New Ireland; Admiralty Group; Papua.

Lutzia halifaxi Theobald.

Mon., Cul. III., 6, 231 (1903).

(Pl. VIII., Fig. 21 a-d.)

Adults were reared from grossly contaminated wells in Rabaul and Mekeo Districts; in the former locality in association with *Culex (Culiciomyia) muticus* Edw., and in the latter with *Culex sitiens* W. They are somewhat smaller and darker than Australian specimens, but no differences have been detected in larvae, pupae or adults to warrant their recognition as a distinct variety.

Culex fatigans Wiedemann.

Aussereur. Zweifl. Ins. I., p. 10 (1828).

The apparent scarcity of this species, as well as *Aedes (Stegomyia) argenteus*, in Samarai and Rabaul is probably due to the efficiency of anti-mosquito measures. A dark variety occurs commonly with the typical form in the undermentioned localities.

Localities: New Britain; New Ireland; New Guinea (Madang); Papua (Moresby, Yule Is., and Samarai).

Culex sitiens Wiedemann.

Aussereur. Zweifl. Ins. I., p. 543 (1828).

(Pl. VIII., Fig. 22 a-c.)

In the vicinity of Rabaul immense numbers of larvae and pupae were found in a small fresh-water pool in the sandy soil near the beach, not far from which the adults were very troublesome. Adults were frequently taken at the hospital, which is situated on the heights overlooking the town. It occurs in all the Papuan villages visited by the writer, and is especially abundant in the Mekeo District. Although larvae and pupae were generally found in fresh or slightly brackish pools and backwaters near

the coast, on many occasions a remarkable concentration was found in canoes drawn up on the sea beach or banks of tidal creeks. In some instances the water contained in the canoes was fresh (according to a native attendant), but in others it was slightly to distinctly saline. In some cases (Moresby District) *Anopheles subpictus* Grassi were associated with *C. sitiens* in canoes containing fresh or slightly brackish water, but, as a rule, when the latter were very plentiful no other larvae were found. Larvae were found in small numbers on Yule Island in the more tranquil parts of a small grass-fringed running stream.

Localities: New Britain; New Guinea (Madang); New Ireland; Ninigo Island; Papua (Samarai, Mekeo and Moresby Districts); Woodlark Island.

Culex cataractarum Edwards.

Bull. Ent. Res. XIV., p. 7 (1923).

The specimens comprising the type series were collected upon a moss and fern-covered rock in a ravine.

Locality: New Britain (Rabaul).

Culex basicinctus Edwards.

Bull. Ent. Res. XII., p. 78 (1921) and XIII., p. 96 (1922).

(Pl. IX., Fig. 23 a-e.)

This species has been reared from a small rain pool on a rock in the Townsville District (Q.).

Culex squamosus Taylor.

Trans. Ent. Soc. 1913, p. 691 (1914) (*Culicada*).

This species has been bred by Dr. Heydon, from plantation drains in the Solomon Group.

Culex (Culiciomyia) muticus Edwards.

Bull. Ent. Res. XIV. p. 6 (1923).

(Pl. IX., Fig. 24 a-f.)

The type series, the larvae and pupae of which are figured here, were bred from a contaminated native well near the sea beach at Rabaul; it has been bred by Dr. Wallace from water contained in a horse-trough. The larval siphon, which is denuded in the specimen figured here, is very long and slender, measuring 1.76 mm. in length by 0.114 in diameter at the middle.

Localities: New Britain; New Ireland; Solomon Group.

Acknowledgments.

Apart from the collections made by the writer in Australia, New Britain and Papua, most of the material dealt with in this paper was collected by Dr. G. M. Heydon, in New Britain and

the Solomon Croup, by Dr. H. G. Wallace, in New Ireland and New Guinea (Madang), by Dr. Backhouse in Admiralty Islands, by Mr. J. Anderson in Woodlark Island, by Dr. Giblin in Samarai, by Dr. Strong and Mr. B. F. Hill in Papua, and Mr. J. Clark in South-West Australia. To the first-mentioned the writer is especially indebted for several recently described *Culicini*, and a large collection of *Anopheles*, with notes on their habits.

In nearly all cases the identifications of species have been made or confirmed by Mr. F. W. Edwards at the request of Dr. G. A. K. Marshall, Director of the Imperial Bureau of Entomology, whose assistance is gratefully acknowledged.

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EXPLANATION OF PLATES.

PLATE V.

Fig. 1.—*Anopheles annulipes* Walker.

a. Palp and proboscis.

b. hind-leg.

f. }

c. } Wings.

d. }

e. }

Fig. 2.—*Anopheles amictus* Edwards.

a. Palp, proboscis and wing (male).

b. }

c. } Palp, proboscis and wing (female).

d. }

e. fore-leg.

f. hind-leg.

Fig. 3.—*Anopheles* ?? *amictus* Edwards.

a. Palp, proboscis and wing.

b. Palp and wing.

c. Palp.

d. Wing.

e. Fore-leg.

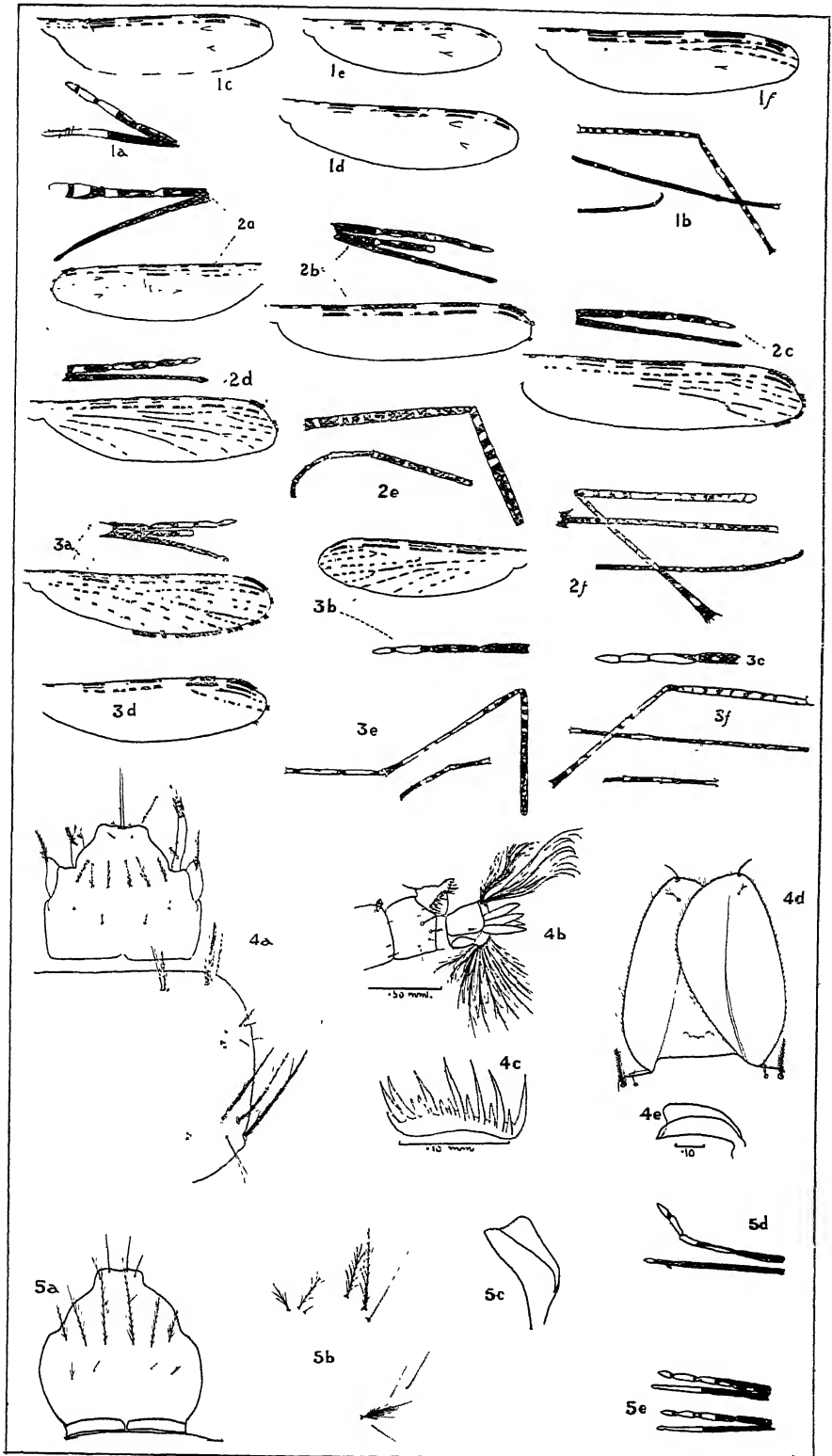
- Fig. 4.—*Bironella gracilis* Theobald.
 a. Larva—head and thorax.
 b. „ posterior segments.
 c. „ comb of 8th segment.
 d. Pupa—paddles.
 e. „ trumpet.
- Fig. 5.—*Anopheles punctulatus* Dönitz.
 a. Larva—head.
 b. „ right shoulder hairs.
 c. Pupa—trumpet.
 d. Adult—proboscis and palp (male).
 e. „ proboscis and palp (female).

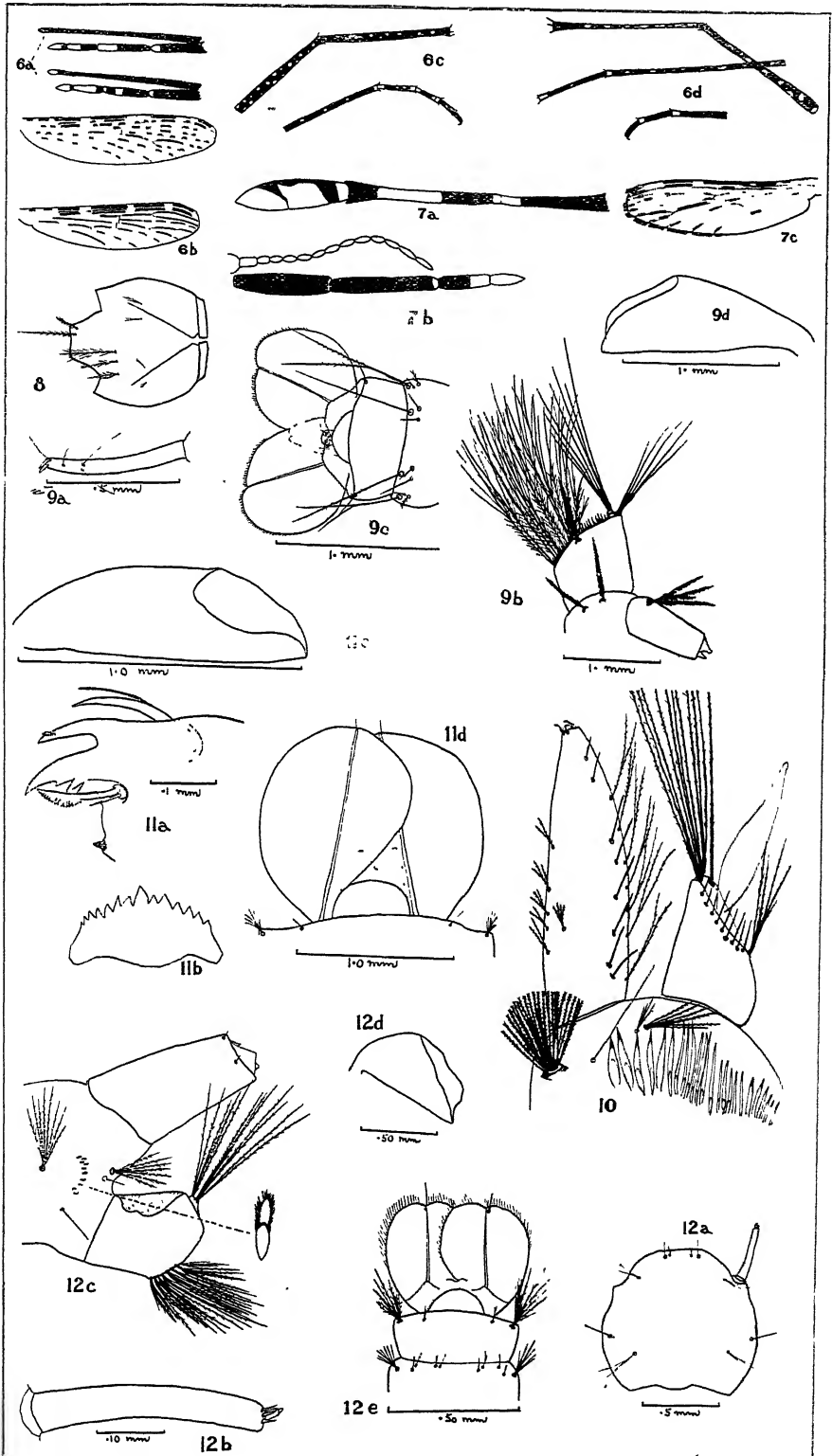
PLATE VI.

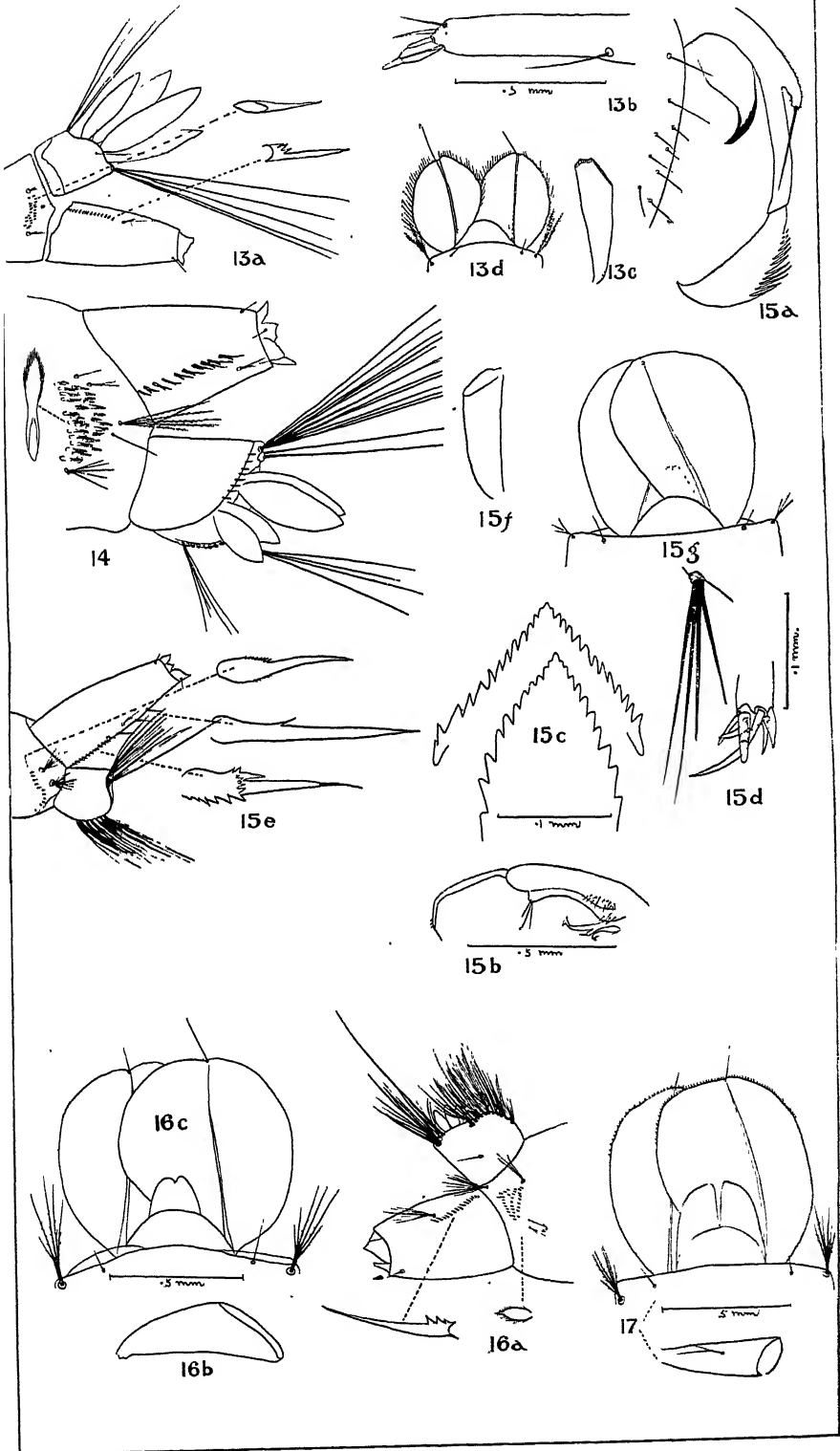
- Fig. 6.—*Anopheles punctulatus*, var. *moluccensis* (Swell.).
 a. Wing, proboscis and palp.
 b. Wing.
 c. fore-leg.
 d. hind-leg.
- Fig. 7.—*Anopheles subpictus* Grassi.
 a. Palp (male).
 b. Palp and antenna (female).
 c. wing.
- Fig. 8.—*Anopheles* sp. ? (from New Britain).
 Larva—Head.
- Fig. 9.—*Megarhinus inornatus* Walker.
 a. Larva—antenna.
 b. „ posterior segments.
 c. Pupa—posterior segments.
 d. „ trumpet.
- Fig. 10.—*Rachionotomyia quasiornata* Taylor.
 Larva—posterior segments.
- Fig. 11.—*Mucidus alternans* Westwood.
 a. Larva—mandible.
 b. „ labial plate.
 c. Pupa—trumpet.
 d. „ paddles.
- Fig. 12.—*Armigeres lacuum* Edwards.
 a. Larva—head.
 b. „ antenna.
 c. „ posterior segments.
 d. Pupa—trumpet.
 e. „ paddles.

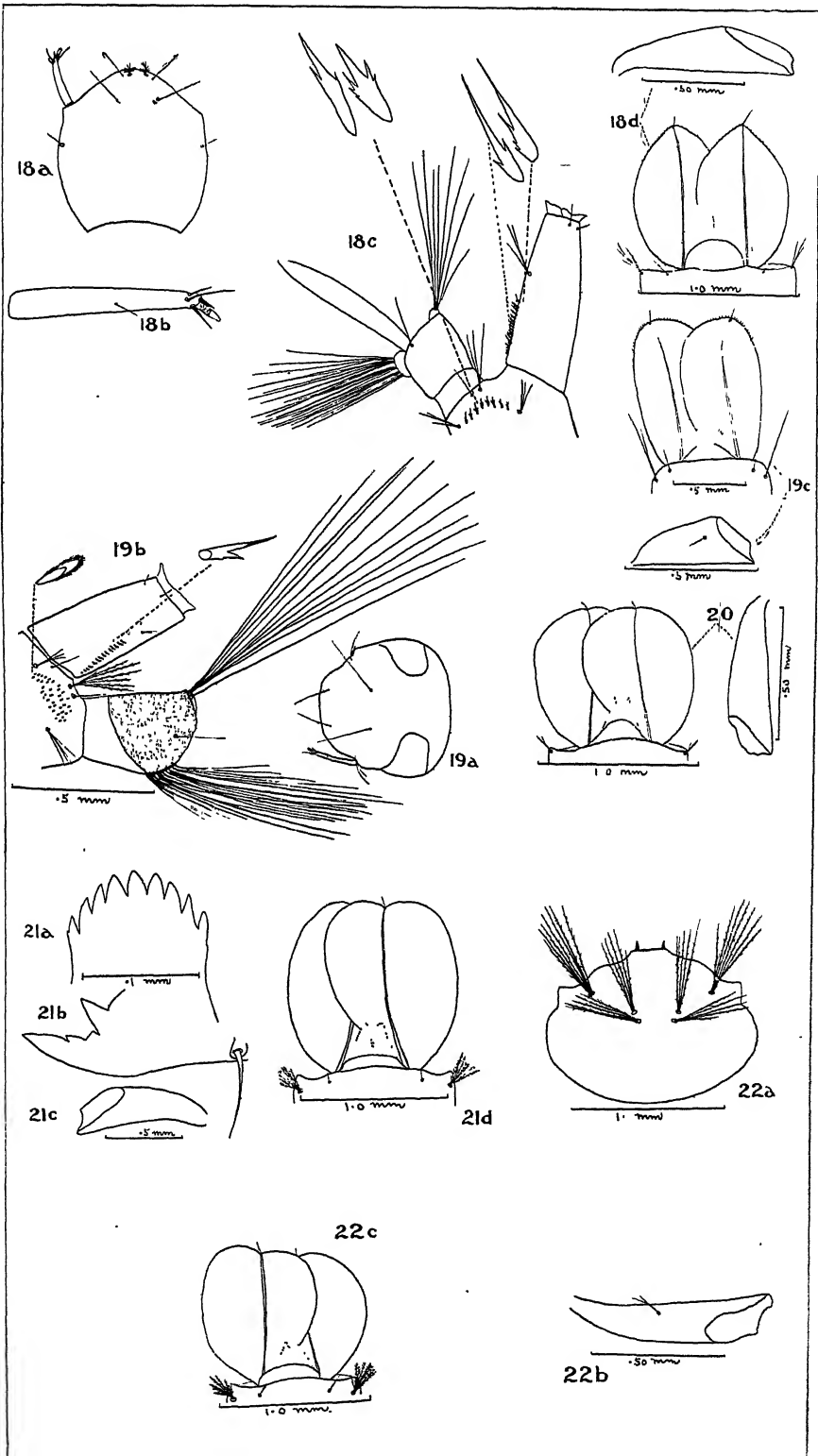
PLATE VII.

- Fig. 13.—*Aedes (Stegomyia) variegatus* (Dol.).
 a. Larva—posterior segments.
 b. „ antenna.
 c. Pupa—trumpet.
 d. „ paddles.









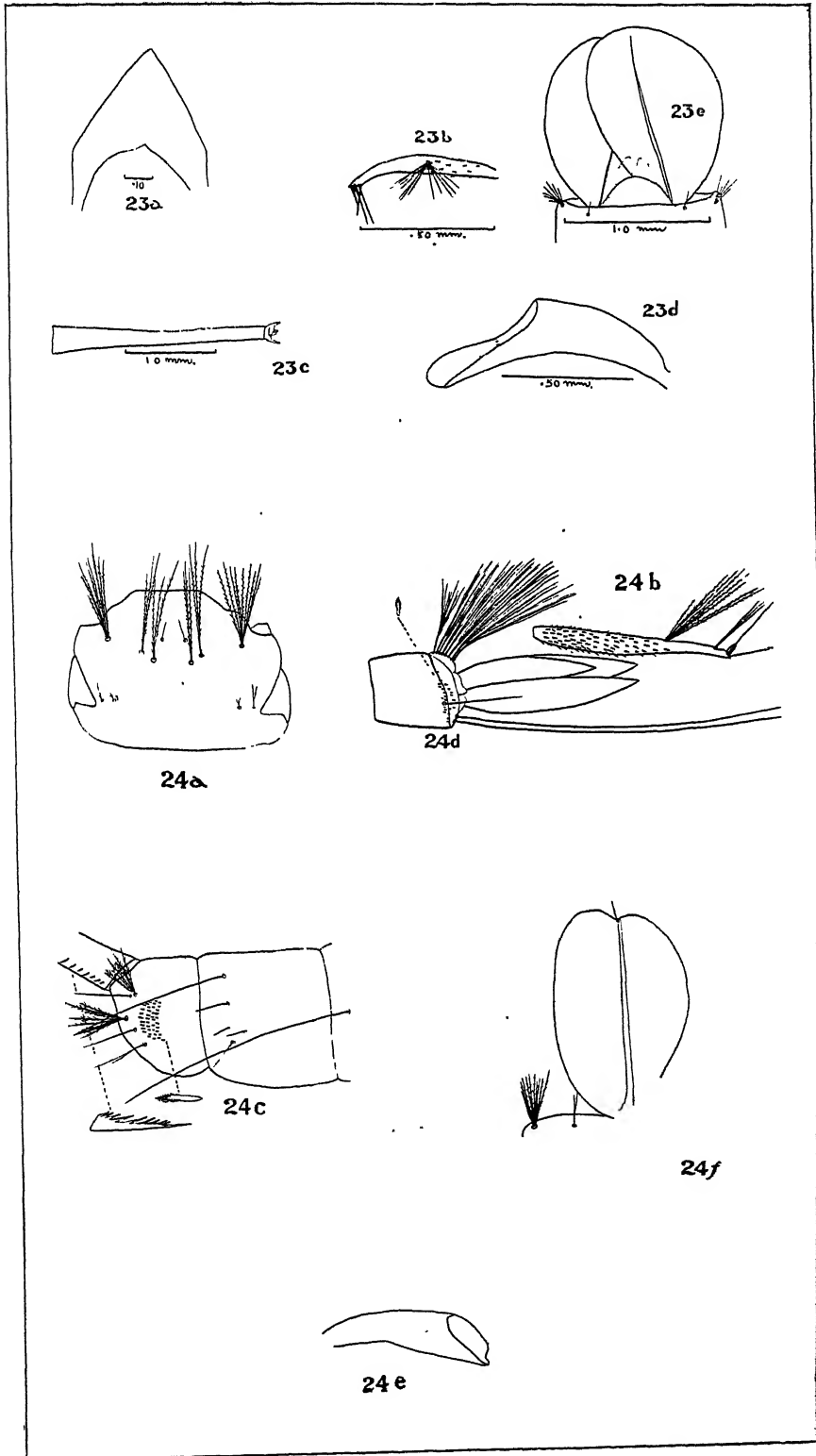


Fig. 14.—*Aedes* (*Stegomyia*) *albolineatus* Theobald

a. Larva—posterior segments.

Fig. 15.—*Aedes* (*Ochlerotatus*) *vittiger* Skuse.

a. Adult male, hypopygium.

b. Adult male, claspette.

c. Larva—labial plate (2 forms).

d. „ apex of antenna and median hair.

e. „ posterior segments.

f. Pupa—trumpet.

g. „ paddles.

Fig. 16.—*Aedes* (*Ochlerotatus*) *vigilar* Skuse.

a. Larva—posterior segments.

b. Pupa—trumpet.

c. „ paddles.

Fig. 17.—*Aedes* (*Finlaya*) *notoscriptus* (Skuse).

Pupa—paddles and trumpet.

PLATE VIII.

Fig. 18.—*Aedes* (*Finlaya*) *quasirubritrithorax* Theobald.

a. Larva—head.

b. „ antenna.

c. „ posterior segments.

d. Pupa—paddles and trumpet.

Fig. 19.—*Aedes* (*Macleaya*) *tremula* (Theobald).

a. Larva—head.

b. „ posterior segments.

c. Pupa—trumpet and paddles.

Fig. 20.—*Aedes* (*Aedes*) *funereus* Theobald.

Pupa—trumpet and paddles.

Fig. 21.—*Lutzia halifaxi* Theobald.

a. Larva—labial plate.

b. „ mandible.

c. Pupa—trumpet.

d. „ paddles.

Fig. 22.—*Culex sitiens* Wiedemann.

a. Larva—head.

b. Pupa—trumpet.

c. „ paddles.

PLATE IX.

Fig. 23.—*Culex basicinctus* Edwards.

a. Larva—labial plate (2 forms).

b. „ antenna.

c. „ siphon.

d. Pupa—trumpet.

e. „ paddles.

Fig. 24.—*Culex* (*Culiciomyia*) *muticus* Edwards.

a. Larva—head.

b. „ antenna.

c. „ 7th and 8th segments.

d. „ 9th segment.

e. Pupa—trumpet.

f. „ paddles.

ART. IV.—*The Nutrient Value of Artificial Sugar.*

By ALFRED J. EWART, D.Sc., Ph.D., F.L.S., F.R.S.

[Read 8th May, 1924.]

In the Proceedings of the Royal Society of Victoria, a method was described of rapidly polymerizing sugar in large quantity from formaldehyde solutions. The material obtained consists of a mixture of sugars with formates and other substances. By dissolving in water and partially precipitating with alcohol, a fair proportion of the sugar can be separated from the other materials.

A sample of 200 grams obtained in this way was dissolved in 5 litres of water containing 10 grams of ammonium nitrate, 10 grams of potassium phosphate, and 5 grams of magnesium sulphate. The flask was kept at 20°C.—30°C., and from time to time the bulk of the organisms filtered off by passing through a porous clay filter. A great variety of organisms developed. At first small pointed yeast cells predominated, but in the later stages mainly two rod-like bacteria were present, one 2 to 4 μ and the other 4 to 10 μ in length. After 10 months the liquid became sterile, and it was assumed that all the nutritious artificial sugars had been used up.

The remaining liquid was filtered and evaporated to a small bulk. After adding its own volume of alcohol, a dark gummy residue separated slowly. (Sample I.) To the filtrate twice its volume of alcohol was added. The precipitate was Sample II. The filtrate was evaporated to dryness, giving the residue, being Sample III.

Dr. Young and Mr. Vickery very kindly examined these samples, and reported in brief as follows:—

Sample I. gave a slight reduction with Fehling's test, but yielded no detectable osazone, and gave only a slight negative rotation (-0.5° through a 2 dm. tube). Estimated by reduction (Bertrand's method), the solution contained 0.04% of sugar expressed as glucose.

Sample II. gave a fair reduction with Fehling's, and a doubtful trace of fermentation. A 6% solution gave -0.16° to 0.017° rotation in a 2 dm. tube. By Bertrand's method it contained 0.15% of sugar, but it did not yield any distinct osazones.

Sample III. gave all the tests for pentose, but yielded no osazones. The greater bulk of the material was included in this sample.

The first sample apparently largely consisted of gummy materials, possibly partly derived from the organisms grown in the liquid. These organisms had removed most, but not all of the more nutritive hexose sugar, leaving very largely the pentoses of Sample III. These pentoses were evidently either unattacked or less vigorously attacked by the micro-organisms. Further investigations in this direction are in progress.

ART. V.—*The Lignotubers of Eucalypt Seedlings.*

By LESLEY R. KERR, M.Sc.

(With Plates X., XI., and 7 Text Figures).

[Read 12th June, 1924].

During their early stages of growth the great majority of the Eucalypts and the Angophoras are characterised by the development of swellings which in many species attain a considerable size. They occur at the base of the stem either at the surface of the soil or just below it. As we shall see later, they are to be classed as tubers on both morphological and physiological grounds, and since they are woody when adult, I suggest for them the name "Lignotubers." In the great majority of forms these lignotubers merge gradually into the stem after the tree attains the young sapling stage. On the whole, their development is least in the gums, considerable in the boxes, and greatest of all in the mallees, where they persist throughout the life of the tree and attain a very large size. In the mallees these rudely globose boles, which form the mallee roots of commerce, are partly subterranean.

Attention was directed to these lignotubers by Tate,⁽¹⁾ who gave a brief account of the species in which he knew them to be present. Later, Jönsson² drew attention to them, stating that they developed under unfavourable conditions of nutrition. He considers that the nature of their growth strongly reminds one of the heteroplasmic correlations mentioned by Ernst Kuster.³ Jönsson was able to produce these swellings or hasten their growth by cutting off the leaves, buds, or twigs.

Vuillemin⁽⁴⁾ described these swellings as being produced by the action of a parasite, *Ustilago vrieseana*, which also produced similar swellings, which he called tumours on other Myrtaceae (*Myrtus*, *Acmena*, *Tristania*, *Melaleuca* and *Callistemon*). Tubeuf and Smith⁵ describe them as being woody tumours, from which proceeded outgrowths resembling "witches brooms." These contained the mycelium of an *Ustilago*, which produced spores in the cortical tissues.

During 1909, McAlpine, at Professor Ewart's request, carefully examined specimens of these so-called diseased seedlings from the State Nurseries at Creswick, but was unable to find any trace of disease organisms. Clayton O. Smith⁽⁶⁾ refers to these swellings as being due to infection entering through the axils of the leaves. He states that he was able to successfully inoculate seedlings of *E. tereticornis* with cultures of soil organisms.

Fletcher and Musson⁽⁷⁾ consider that they are similar in nature to crown galls, in which the organisms are confined to the

encircling tumours to which they give rise, and do not invade the rest of the stem of the seedling. They recognise three groups according to whether the Eucalypts are—(1) liable to attack, (2) resistant or refractory, (3) exempt from the attacks of the supposed parasitic soil organisms causing the tumour formation. They consider the parasites enter through the leaf axils. In addition they regard the tumours as being a drag on the normal development of the plant, and not natural growths. They published an interesting series of photographs showing the relative size of the growths and their development in different species.

Development.

Typically these lignotubers arise in the axils of the cotyledons as a pair of lateral outgrowths, which gradually increase in size until they meet, forming a swelling which encircles the stem. Pl. X., Fig. E, shows a specimen of *E. globulus*, in which fusion has just commenced. Later on, other pairs of swellings may arise in the axils of the leaves. These also increase in size, and finally fuse in pairs encircling the stem. As these further increase in size they gradually come to meet and fusion in the vertical direction takes place, resulting in a much elongated swelling, e.g., *E. amygdalina*, *E. elaeophora*, *E. sideroxylon*, etc. In cases where typically only a single pair arises, the result is a more or less rounded swelling encircling the stem, e.g., *E. globulus*, *E. Maideni*, etc.

By the time these swellings have attained a considerable size they have usually extended sufficiently far towards the base of the plant to encircle some of the roots. Pl. X., Fig. A, shows a specimen of *E. melliodora*, where a root has been incorporated and the encircling of a second one is commencing. In some cases secondary roots may develop from them, as shown in Pl. X., Fig. F. Under natural conditions these swellings may be considerably distorted in shape by coming into contact with hard objects, which stop their growth at the point of contact. If this occurs when the lignotubers are just commencing, it may cause the appearance of what looks like three in a whorl instead of two.

Growth under favourable conditions of nutrition results in a smooth surfaced swelling, but if subjected alternately to favourable and unfavourable conditions, they develop a very irregular surface. At certain points the bark is thinner, and after any arrest of growth by unfavourable conditions, growth is resumed most actively at these points, resulting in an irregularly lobulated surface.

There are exceptional cases in which the lignotubers occur either on the internodes after the ones in the axils of the cotyledons have appeared or one side of the stem only. In rare cases they develop on the hypocotyl below the cotyledons, as shown in

Pl. X., Fig. E. This frequently occurs in *E. corymbosa* and *E. exima*, but rarely in other species.

Considerable variation is shown in the number developed in a single species. Pl. XI., Fig. A, shows specimens of *E. numerosa*, where in one case there are as many as twelve pairs present, but where in another case in an older seedling only a single pair is present. But on the whole, the tendency is to produce a number fairly constant in the species. Thus *E. globulus*, *E. Maidenii*, etc., normally develop a single pair of lignotubers, as seen in Pl. XI., Fig. B, while *E. sideroxylon*, *E. eugenoides*, *E. piperita*, *E. polyanthemos*, *E. coriacea*, and many others, produce many pairs. Pl. XI., Fig. A, shows a series of seedlings of *E. numerosa*, illustrating the development from a single unfused pair to a final one, consisting of a large pyriform swelling, which has resulted from the fusion of many pairs. In cases where an exceptionally large number are produced the upper ones, mainly due to the greater elongation of the internodes, may not attain a sufficiently large size to fuse with the lower ones and in such cases remain separated. This often occurs in *E. eugenoides*.

These swellings increase in size until the tree has entered on the young sapling stage, when the stem begins to thicken more rapidly than the lignotubers, and finally they become merged into the stem and disappear. In a few cases they persist throughout the life of the tree. Growing on the top of Anthony's Cutting, near Bacchus Marsh, there are three fully mature trees of *E. hemiphloia* var. *microcarpa* (Pl. X., Fig. H), and they have retained well marked swellings at the base. I have also seen several specimens of *E. sideroxylon*, and one of *E. melliodora*, which still show them in the mature tree. Although I have examined a large number I have never seen a swelling persisting in a species which inhabits the moister and better situations.

Many saplings were observed under natural conditions, and the maximum diameters of the lignotubers compared to the stem were measured together with the height of the sapling. The following are averages for species, one from a moist and three from dry localities:—

Species.	Av. diameter of the lignotubers.	Av. diameter of the stem.	Height.
<i>E. macrorrhyncha</i>	12 cms.	5.6 cms.	210 cms.
<i>E. elaeophora</i>	13 cms.	6.5 cms.	300 cms.
<i>E. sideroxylon</i>	14 cms.	6.5 cms.	180 cms.
<i>E. globulus</i> var. <i>St. Johnii</i>	6.5 cms.	3.5 cms.	360 cms.

After this the size of the trunk increased more rapidly than that of the swelling, which remains almost the same, and gradually merges into the stem.

The species, which do not inhabit regions of uncertain climate, show no development of lignotubers. As far as I am aware, the following species show no development of them: *E. diversicolor*, *E. gigantea* (*E. Delegatensis*), *E. oreades*, *E. pilularis*, *E. regnans*

and *E. regnans* var. *fastigata*. It is significant that all the above species inhabit regions where the rainfall is good and fairly evenly distributed throughout the year, so that there is little chance of them suffering from drought. Fletcher and Musson⁽⁷⁾ describe *E. punctata* as being immune from these swellings, but as a matter of fact seedlings of this species show well developed lignotubers which may first appear in nursery seedlings when only twelve centimetres in height.

Species inhabiting regions which only suffer from a short period of drought towards the end of the summer attain a much greater height before they show any signs of the development of these swellings, e.g., *E. globulus*, *E. rostrata*, *E. saligna*, etc., than those in drier regions. These may attain a height of as much as 90 cms. in well lighted situations, and are from 14-30 weeks old before the lignotubers begin to appear. In the majority of cases they begin to develop when the seedlings are from 36-50 cms. high. On the other hand species inhabiting regions liable to drought develop them very early, e.g., *E. crythrocorys*, which begins to develop them as soon as it has two pairs of well developed leaves. Maiden⁽⁸⁾ states that this species grows in the dry arid regions of Western Australia. In these situations there is usually a short wet, warm period, when growth is very active, which is followed by a prolonged dry spell. Specimens of this species in the nurseries of Messrs. G. Brunning and Son, four centimetres in height, had a pair of well-developed lignotubers each the size of a radish seed. Greenhouse specimens of *E. Priesiana* commenced to develop the swellings when six centimetres in height and eight weeks old, while *E. tetraptera* was only five centimetres in height and nine weeks old. When it was twenty-eight weeks old it possessed two pairs of swellings eleven and nine centimetres respectively in diameter.

Among the boxes, ironbarks, stringybarks and peppermints, e.g., *E. hemiphloia*, *E. polyanthemos*, *E. melliodora*, *E. sideroxylon*, *E. macrorrhyncha*, *E. obliqua*, and many other forms inhabiting regions of uncertain climate, the development began when the seedlings were from nine to sixteen centimetres in height and nine to twelve weeks old. The greenhouse in which these seedlings were raised is unheated and rather badly lit, consequently the lignotubers were slightly later developing, and the seedlings attained a height greater than they do under natural well lit conditions, but they serve for comparison, as all were under exactly the same conditions. In the field species, such as *E. macrorrhyncha*, *E. elaeophora*, *E. numerosa*, and many others show signs of the development of lignotubers when from four to seven centimetres in height, and when their age is not more than ten weeks at the outside. Thus on the whole, the more uncertain the climate of the locality in which a species naturally is found, the greater is the development of the lignotubers and the earlier they appear in the seedling. Thus the gums, e.g., *E. globulus*, *E. saligna*, *E. rostrata*, etc., under greenhouse conditions, develop them when from

fourteen to twenty-eight weeks old, and from thirty-six to fifty centimetres or more in height, while the boxes and similar forms develop them when from nine to twelve weeks old and nine to sixteen centimetres in height, and the species from the dry arid regions of Western and Central Australia, when from eight to nine weeks old, and three to four centimetres in height. Moreover, these forms from the hot, dry interior were considerably retarded in their development by the cool summer of 1923-24, when they were under observation.

Species which develop these swellings possess a remarkable power of producing new growth either when cut down or injured by fire. A tree of *E. hemiphloia* var. *albens* cut down four inches from the ground in July, 1923, has since produced large numbers of shoots, which were removed as soon as formed (almost every week). During January of the following year, an attempt was made to remove it by burning, but four weeks later it produced fourteen new shoots from below the charred part. It was still sprouting freely in May. In contrast to this is *E. regnans*, which produces no lignotubers, and when cut down does not sprout again. In addition to their powers of producing new growth these forms transplant very readily even when not given the most careful treatment, while species like *E. regnans* only do so when handled with the greatest care.

Lack of insolation considerably retards the formation of the lignotubers, and causes a later and a smaller development. Pl. XI., Fig. D, shows two specimens of *E. elaeophora* and Fig. B. of *E. globulus* var. *St. Johnii*, one of which was grown in the full sunlight while the other was shaded by means of frosted glass. Those which were subjected to fairly intense insolation show a larger leaf area and a much greater and earlier development of the lignotubers than those which were shaded. Seedlings of *E. elaeophora* five months old under the latter conditions presented a drawn appearance, and were just commencing to develop the swellings, while in *E. globulus* var. *St. Johnii*, in a seedling eleven months old they have not commenced to fuse. In the unshaded seedling, however, fusion has taken place. This was also very striking in the field where seedlings growing in situations subjected to fairly intense insolation showed a larger and an earlier development of the swellings than those in the more shaded situations. Seedlings of *E. macrorrhyncha* and *E. elaeophora* showed the early stages of the development when from four to six centimetres in height, while those in the more shaded situations averaged twelve to twenty centimetres in height.

In handling large numbers of these seedlings one notices a very definite relationship between the leaf area and the size of the lignotubers. Seedlings bearing unhealthy or diseased foliage produced either very small lignotubers or none at all. I raised a seedling of *E. coriacea*, which later became attacked by a "witches broom" fungus. Before the fungus attacked the seedling it possessed a small pair of lignotubers, but as soon as the disease

gained a hold no further development took place. The seedling developed a large amount of wood, but a scanty leaf area.

Under natural conditions the development of lignotubers in a species bearing them is not a variable but a constant feature. Seedlings raised under nursery conditions and meeting with an accident to the root system either produce no lignotubers or very small ones. Pl. XI., Fig. E, shows two seedlings of *E. coriacea* five months old—(1) had portion of the radicle removed when pricked off, and made little growth, and developed no lignotubers, while (2) is a normal seedling. Pl. XI., Fig. F, shows the same two seedlings when eleven months old. Badly drained soil produces a similar effect.

Checking the growth by removal of the growing point causes a considerable increase in the size of the lignotubers, provided that there is a fair proportion of leaf area. Keeping the seedlings in a rather small pot, and thus checking the growth produces the same result. In all cases when the most active growth of the seedling is taking place, the development of the lignotubers is at a standstill, but as soon as the rate of growth slows down, the rate of increase in the size of the lignotubers is very marked. In all cases the largest and strongest plants produce the largest lignotubers. If the lignotubers are excised they are rapidly formed again.

The application of suitable fertilisers greatly increases the size of the lignotubers. In all cases calcium superphosphate, followed by nitrates, was the most effective, while potash had but little effect. The seedlings were grown in ordinary potting soil, so that the mineral fertilisers exercised less effect than if they had been grown in sand, but even then the effect of superphosphate was very marked. In all cases the seedlings showed rapid early growth, and the lignotubers commenced to develop as soon as the rate of growth slows down, and rapidly increase in diameter. Pl. XI., Fig. C, shows three seedlings of *E. clacophora*, grown in four-inch pots, in ordinary soil; (a) is the control, (b) was watered at intervals for six months with 1 in 10,000 potassium nitrate, and (c) with a similar solution of calcium superphosphate. The beneficial effect of the superphosphate is very striking. Similar results were obtained with *E. globulus*, *E. ficifolia*, *E. rostrata*, and *E. leucoxylon*, but failed to produce any lignotubers in *E. diversicolor*.

In addition to appearing on seedlings, these swellings are occasionally found on active new growth formed from a tree or a sapling which has been cut down or injured by fire. In these cases they appear towards the base of the shoot either as a single pair of lignotubers or as a number placed along the stem generally at the nodes. Pl. X., Fig. B, shows two specimens of *E. polyanthemos* five weeks and nine weeks after the removal of their shoots, which took place when they were fourteen months old. The lignotubers are developing at the nodes. Pl. X., Fig. D, shows a specimen of *E. numcroşa*, the original sapling of which was

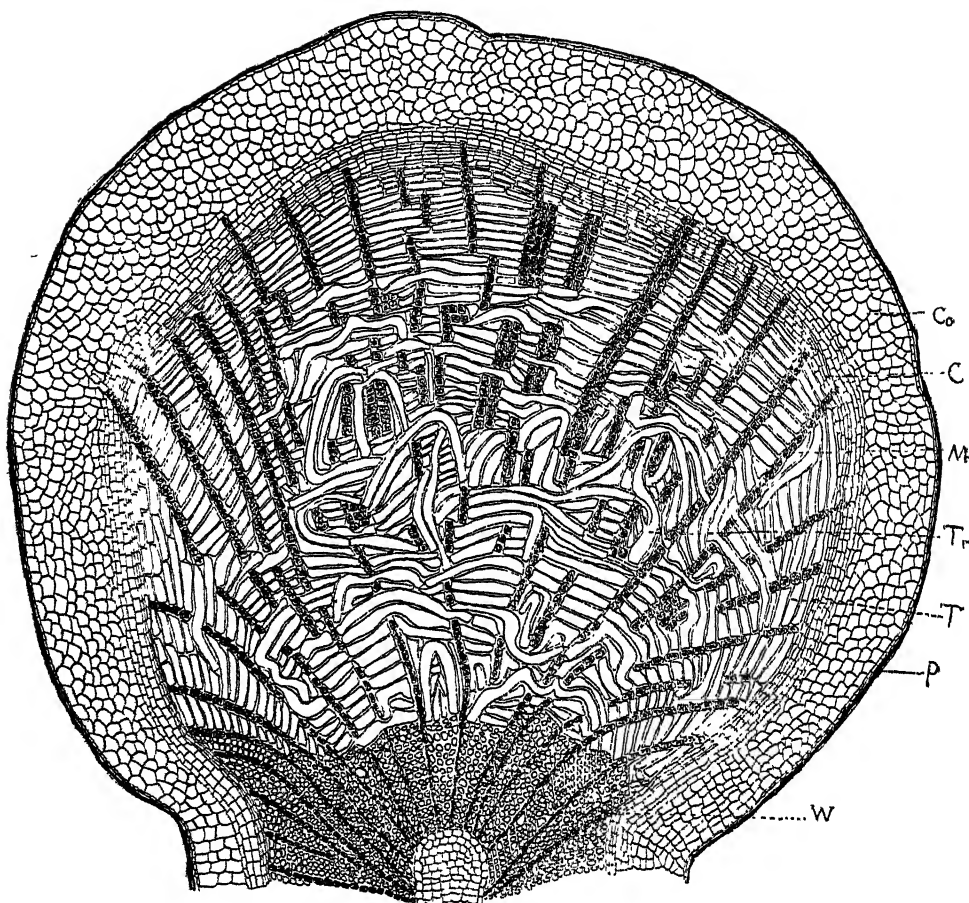
attacked by *Armillaria* on one side in particular. A small strand of living wood remained after the sapling fell, and gave rise to the shoots bearing the lignotubers. From the dead wood a large fructification of the fungus developed, but this unfortunately was knocked off when being brought back for photographic purposes. A single specimen of *E. goniocalyx* was found where a shoot had developed directly from the root of a fallen tree. A large lignotuber developed at the base of the shoot.

The above observations seem to indicate that the lignotubers are merely embryonic storage organs developed in order to enable the seedlings to survive temporary unfavourable conditions. In support of this is the fact that the lignotubers, particularly in the species inhabiting the regions of more uncertain climate, produce large numbers of buds which, should the main stem be injured, develop and carry on the growth of the plant. Pl. X., Fig. A, shows three specimens of *E. melliodora*, in (1) the growth is carried on by the main stem, but in (2) and (3) the main stem has been removed, and the growth is carried on by shoots arising from the lignotubers. Further evidence is also afforded by the structure of the lignotubers, the nature of the food materials, and the changes which these undergo.

Structure.

The lignotubers arise in the axils of the cotyledons as proliferating outgrowths of tissue from the cambium. The greater part of the young lignotuber consists of a large number of curiously interlaced thickwalled tracheae with medullary rays occurring at intervals between them. Text-fig. I. shows a section during a very early stage of development when the twisting of the tracheae is just commencing.

These tracheae (T) develop from rows of brick shaped cambial segments which gradually elongate and fuse. As they increase in size they become much curved or twisted. Text-fig. 1 shows the twisting commencing. In all probability this results from the fact that active growth in the horizontal plane is taking place, whereas very little elongation is going on. When the lignotuber has further increased in size the twisting of the tracheae is very marked, and small rays of wood begin to appear. Text-fig. 2 shows six such rays (W). These gradually increase in size, and new ones form as the age of the lignotuber increases. Their development is usually not symmetrical, and more rays frequently appear on one side than on the other, as shown in Text-fig. 2.



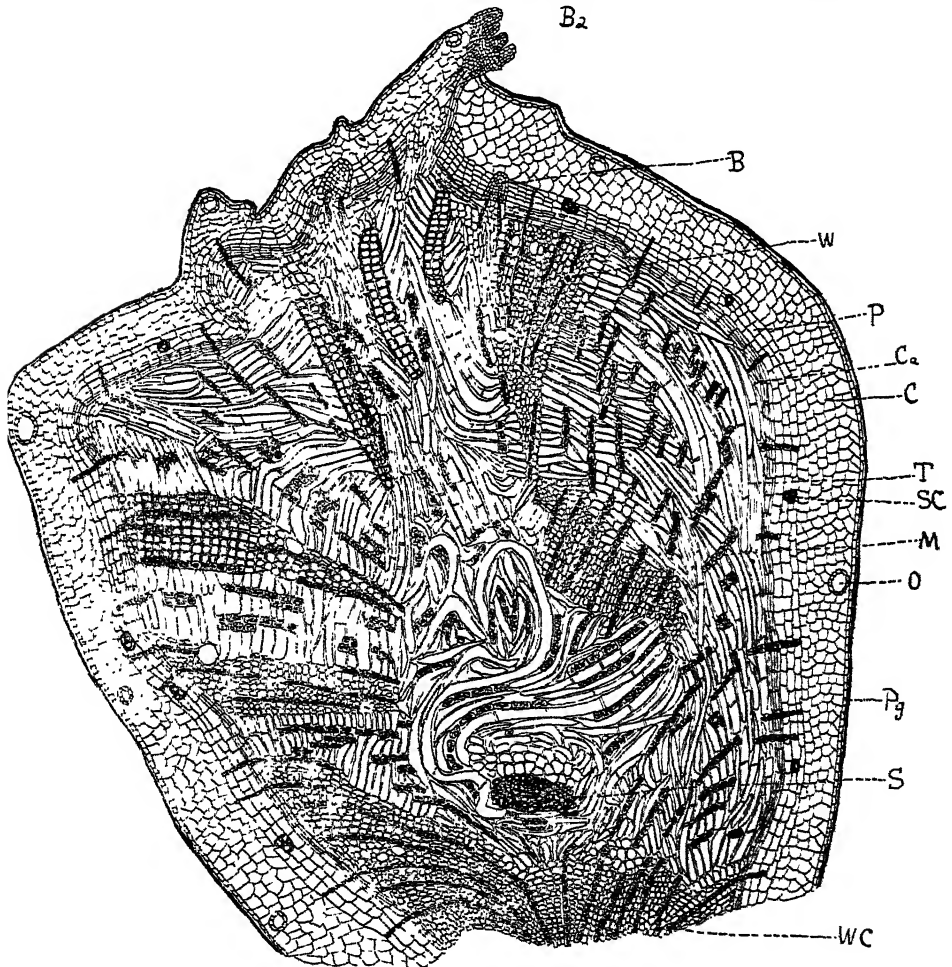
TEXT FIGURE 1.

Transverse section of a lignotuber of *E. Morrisii*, 12 weeks old. C, cambium; Co, cortex; M, medullary rays; P, phellogen; T, phloetracheae; Tr, phlebotracheae enlarging and beginning to twist; W, wood of the main stem. $\times 31$.

These rays of wood always appear at the points where growth is least active, and generally make their appearance when the lignotuber is eight to ten weeks or more old. The time of their appearance is, however, liable to considerable individual variation. In the wood tyloses are of frequent occurrence, more particularly in the wood of the main stem. At this stage also a small group of stone cells (S) appears, and occupies the position shown in the figure, which is the original centre of the swelling. In some cases other groups or more than one group, is formed.

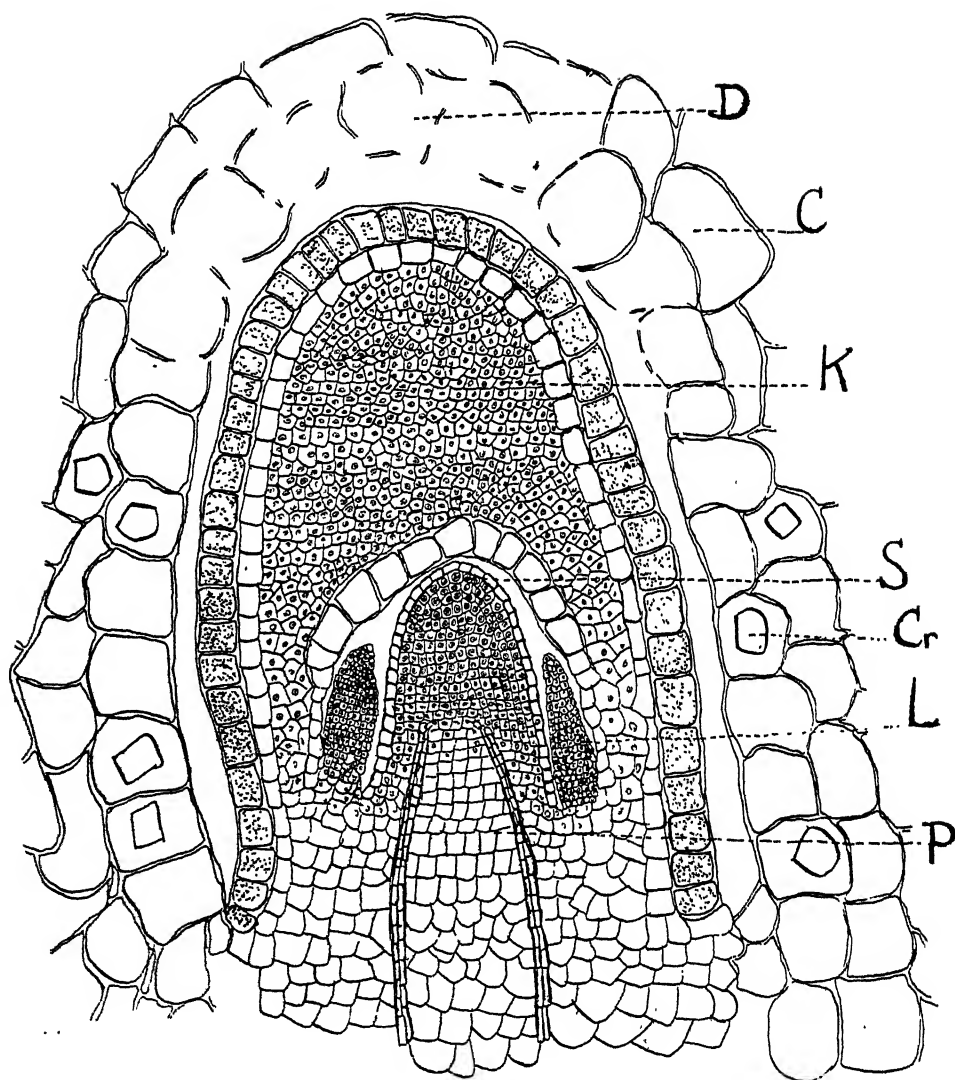
Around this group of stone cells the greatest twisting of the tracheae occurs.

Arising from the cambium are buds (B), which are peculiarly deep seated in their origin. These gradually come to lie on the surface, and give rise to new shoots as seen at (B₂), which is not cut in the median plane. Very large numbers of these buds may develop, particularly if any injury should arise to the main stem when the growth of the seedling is carried on by them. Fletcher



TEXT FIGURE 2.

Transverse section of a lignotuber of *E. coriacea*, 8 months old. B, bud; B₂, bud on the surface; C, cortex; Ca, cambium; M, medullary rays; O, oil duct; P, secondary phloem; Pg, phellogen; S, stone cells; SC, stone cells of secondary phloem; T, phloetracheae; W, ray of wood growing in; WC, wood cylinder of the main stem. × 27.



TEXT FIGURE 3.

Longitudinal section of a bud showing the digestive cap commencing to separate from the growing point, and the cortical cells being dissolved. C, cortex; Cr, crystals of calcium oxalate; D, disintegrating cortical cells; K, digestive cap of cells covering the growing tips; L, rudimentary leaves; P, procambial strands; S, apical meristem. $\times 375$.

and Musson⁽⁷⁾ describe the lignotubers as taking possession of the dormant buds and incorporating them, and that this is how these as well as the composite tumours to which they give rise come to have buds or shoots. In reality the buds are of deep-seated cambial origin, and they arise *de novo* internally, and appear on the surface later. These buds are covered by a digestive cap of cells (Text-fig. 3K) similar to that present in roots. When the bud reaches the surface of the lignotuber this digestive cap separates from the growing tip.

The cortex (C, Text-figs. 1 and 2) is narrow, and crystals of calcium oxalate are abundant in the cells. When twelve to eighteen months old phelloderm is formed (Text-fig. 4). The cells are smaller and thicker walled than the cortical cells, and also contain crystals of calcium oxalate. Oil ducts (Text-fig. 2, O) occur at intervals.

As the swelling increases still further in size, the arrangement of the parts becomes more symmetrical, and the twisting less evident, until finally it has much the appearance of a stem with broad bands of pitted tracheae (Text-fig. 4, Pt), occurring between the rays of wood (W). The tracheae from now on become shorter and wider, compared with those of the earlier stage. This structure is shown by the time the swelling is three to four centimetres in diameter, but considerable variations occur.

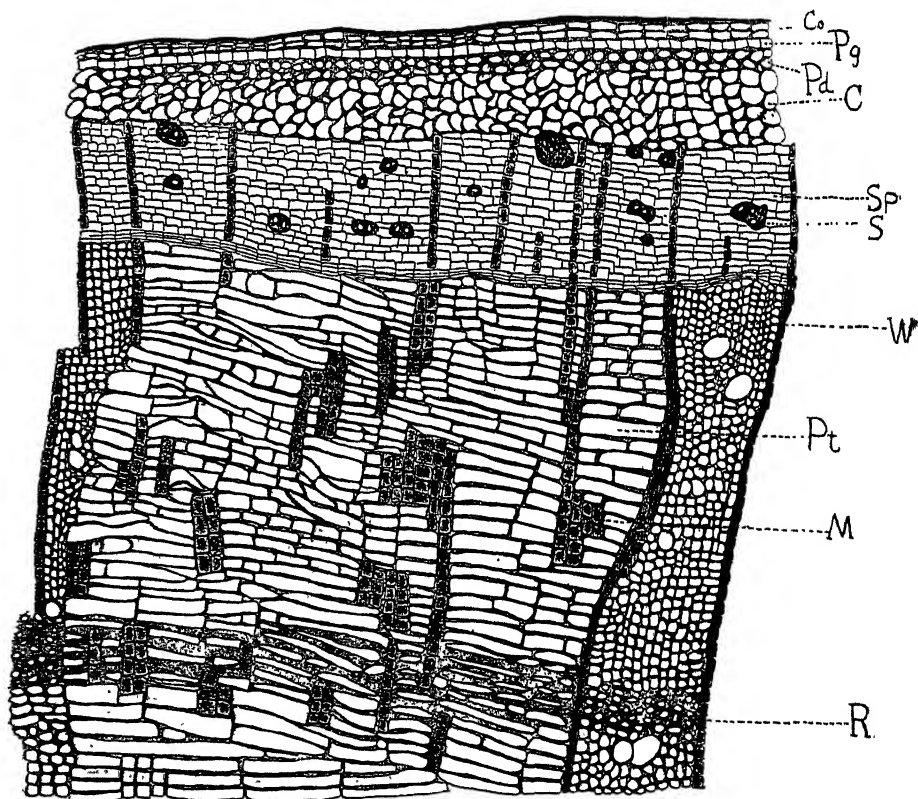
The secondary phloem is well developed with bands of medullary rays running through it. At this stage it contains stone cells (S) similar to those formed at the original centre, either in groups or as isolated cells. These also occur in many cases in the cortex. The sections show distinct bands of smaller very thick-walled elements (R), reminding one of the autumn wood in secondary growth, and which correspond to the less active periods of growth. This type of structure persists until the lignotuber attains its maximum size. After this the diameter growth of the stem overtakes that of the lignotuber, and its surface becomes continuous with that of the stem, the cambium now developing layers of wood homologous with that of the stem. Plate X., Fig. G, shows a specimen of *E. globulus* var. *St. Johnii* 6.5 cms. in diameter, where the lignotubers have commenced to merge into the stem.

The tracheae vary considerably in length, being longest during the earlier stages of growth of the lignotuber, and gradually becoming shorter and more regular in their arrangement as the swelling becomes larger. They present many features in common with the tracheids of *Exocarpus*, which have been called phloeo-tracheids by Benson.⁽⁹⁾ For them I suggest the name of *phloeo-tracheae*. They are thick-walled with a particularly well developed system of bordered pits. The middle lamella is well defined, and the pits are oval in shape, with their longest axis transverse or obliquely transverse (Text-fig. 5).

The walls consist when young entirely of cellulose, but they later become lignified. The distance between the pits and the thickness of the walls varies considerably in the one section. Between the phloeotracheae the medullary rays (M) occur. When quite young their walls are unthickened, but later they become considerably thickened with pitted walls, as shown in Text-fig. 5. Occasionally ones occur with few or no pits, and much thinner walls (Mr).

The whole of the phloeotracheae and the cells of the medullary rays are packed full of food materials, the greater bulk of which is starch in the form of either simple concentric, bicomponent, or tricomponent grains.

The medullary rays contain small amounts of starch, and numbers of aleurone grains (A), as shown in Text-fig. 6 after special staining. The aleurone grains are circular with the

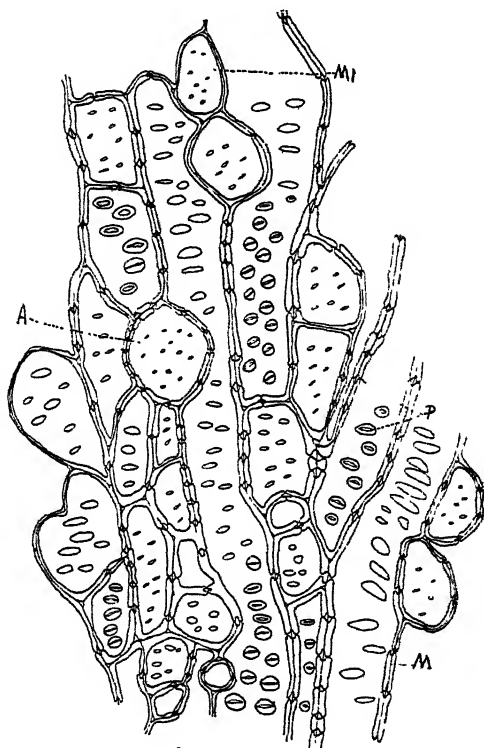


TEXT FIGURE 4.

Portion of a transverse section of a lignotuber of *E. viminalis*, 24 months old. C, cortex; Co, cork; M, medullary rays; Pd, phelloderm; Pg, phellogen; Pt, phloeotracheae; R, ring of thick-walled elements; S, stone cells; Sp, secondary phloem; W, ray of wood. $\times 51$.

globoid (G) surrounded by the larger crystalloid (C). The whole is surrounded by a well defined wall (W).

Normally fats or oils (excluding essential oils) do not occur, but they may occur in species under exceptionally adverse conditions. Considerable amounts were present in a lignotuber of *E. corynocalyx* which had been inarched on to *E. robusta*. The inarching appeared to exercise an inhibitory effect on the growth



TEXT FIGURE 5.

Portion of transverse section of lignotuber of *E. marginata*, 5 months old. A, medullary ray cell with thickened pitted walls; M, middle lamella; Mr, medullary ray cell with thinner unpitted walls; P, bordered pits. $\times 187$.

of *E. corynocalyx*, and it is possible that the appearance of the oil may have been a secondary result of the influence exercised by the inarching with *E. robusta*. The normal food materials starch and aleurone were almost absent.

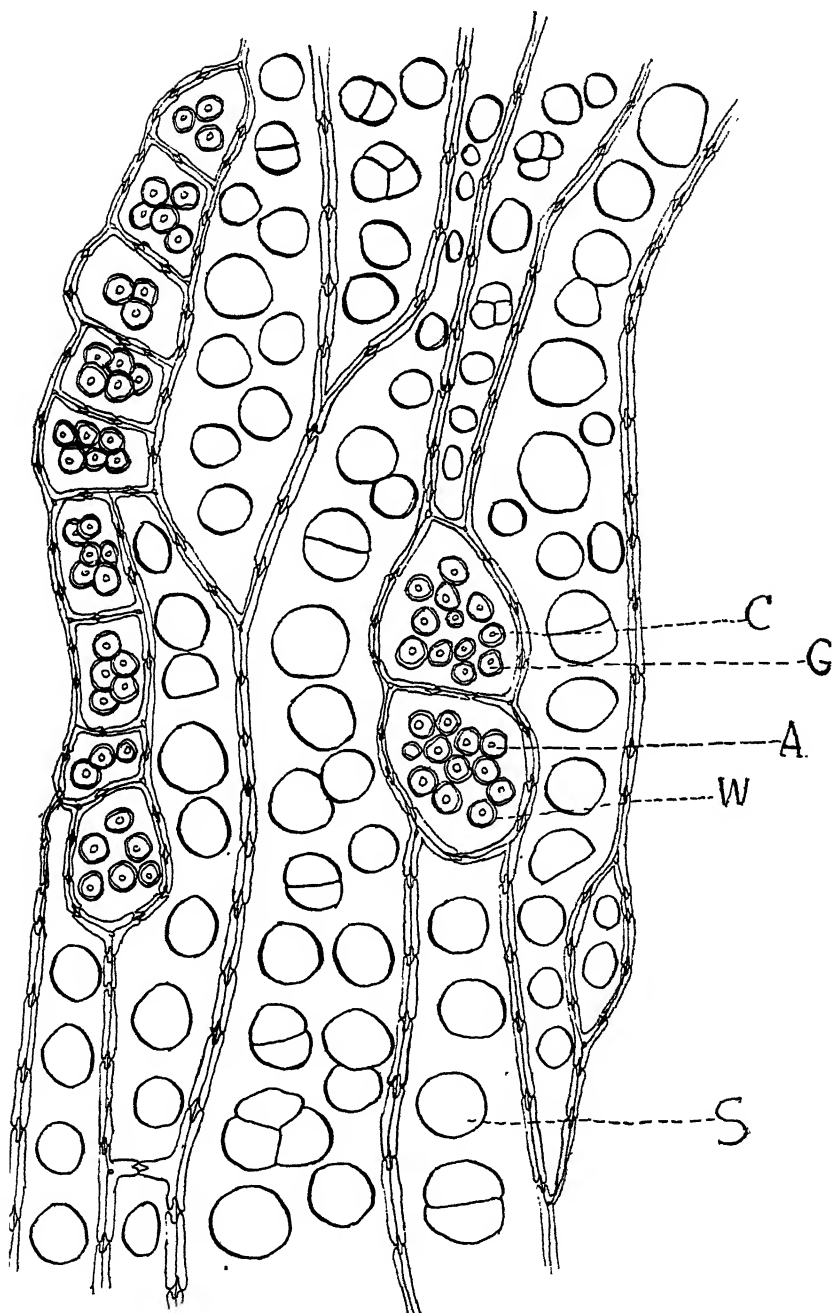
The cortex and bark are rich in a readily soluble tannin of the pyrocatechol series. Since this tannin is a glucoside in all probability it has a certain nutritive value as a reserve material.

When the seedlings are subjected to adverse or abnormal conditions which affect the plant's nutrition, the starch in the lignotubers diminishes. If the conditions are prolonged the protein food materials also diminish. These food materials are rapidly replaced on the return of normal conditions of nutrition. Drought or any condition interfering with assimilation may act in this way.

Seedlings of *E. elaeophora* 22 centimetres in height, which had been developing the lignotubers for one month, and possessed two pairs of lignotubers 0.6 cms. and 0.25 cms. in diameter, were severely injured by excessive cyaniding. In five weeks they used up all the starch in the upper (smaller) pair and half the amount present in the lower pair. At the end of the five weeks they had again resumed active growth, and in four weeks were beginning to accumulate starch again, while in eight weeks the cells were full again. The weather was cold, and this retarded the reappearance of the starch.

Seedlings of *E. globulus* 4.6 cms. in diameter grew in distilled water for fourteen weeks before completely exhausting all the supplies of food, while seedlings of *E. macrorrhyncha* and *E. elaeophora*, 22 cms. high, with a pair of swellings 0.8 cms. in diameter used all the starch and portion of the protein, and were corroding the thickened walls of the phloetracheae after one month in distilled water. During this period the plants produced a considerable amount of new growth in excess of their rate of assimilation and this was developed at the expense of the stored food materials.

Intense cold causes a conversion of the starch to sugar, with a reversion when the temperature rises. The conversion begins by an abundant formation of soluble starch. Seedlings of *E. globulus* var. *St. Johnii*, 3.5 cms. in diameter normally contain 0.05 gms. of glucose, but after twelve days at 5° centigrade, no starch was present, and the sugar had increased to approximately 10%. The starch turns directly to glucose, and gives the characteristic osazone in abundance. Normally there is not sufficient present to do this. Seedlings of *E. macrorrhyncha* 11 cms. high, with two pairs of lignotubers, 0.76 and 0.2 cms. in diameter, after six days at 10° centigrade, showed only odd starch grains here and there, but in three days at 20° centigrade the cells were completely full again. Lignotubers of *E. globulus* var. *St. Johnii*, 3.5 cms. in diameter, after six days at 10° centigrade, had approximately half the normal amount present together, with large amounts of soluble starch, while the remaining starch grains were distinctly corroded. The normal amount was restored in three days at 20°C. Lignotubers 6 cms. in diameter required twelve days at 5° centigrade to completely transform all the starch to sugar. In four days half the normal amount was restored, and in seven days the whole. Apparently the younger lignotubers with less lignified walls can convert starch into sugar more rapidly than in the older ones. In any case this rapid con-



TEXT FIGURE 6.

Portion of a transverse section of a lignotuber of *E. macrorrhyncha*. A, aleurone grains; C, crystalloid; G, globoid; S, starch grain; W, wall of aleurone grain. $\times 375$.

version of starch into sugar is of considerable interest. The presence of the sugar will lower the freezing point for the lignotuber, and will hence serve to protect it against the effects of low temperatures or frost, which might kill the more exposed or less adaptive parts of the plant.

Artificial Infection Experiments.—Several attempts were made by injecting one seedling with an extract of the lignotubers of another seedling to produce them artificially.

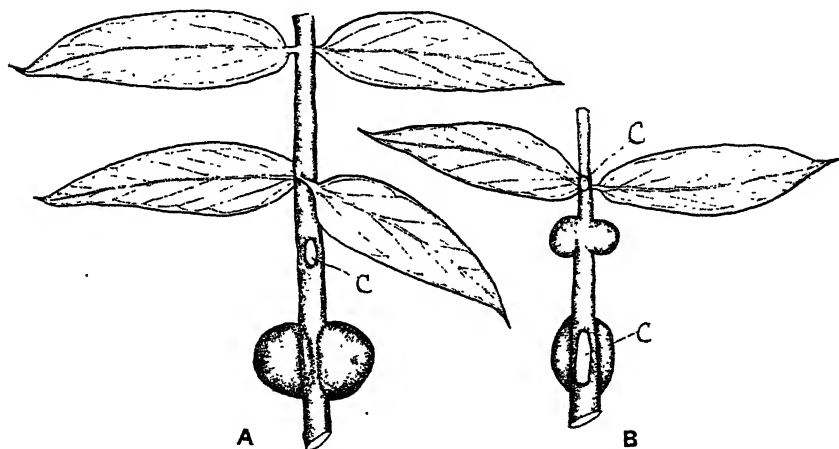
Text-fig. 7 shows two seedlings of *E. coriacea*. A, was inoculated with an extract from one of its own lignotubers on the internode; B, with the same extract in the axil of the cotyledon opposite an unpaired lignotuber, and in the axils of the first pair of leaves. In all cases the prick from the hypodermic needle was healed over by a callus without the least sign of a lignotuber appearing. A prick from a sterilised needle gave the same results. The following species were tried: *E. amygdalina*, *E. cornuta*, *E. numerosa*, *E. peltata*, *E. Morrisii*, *E. diversicolor*, *E. melliodora*, and *E. hemiphloia* var. *albens*.

Sterilised seeds of *E. amygdalina* and *E. clacophora* were sown in sterilised soil. The seedlings were watered with boiled water, and grown away from external sources of infection. After the usual lapse of time lignotubers of the normal seedling character appeared. There is no evidence (1) that the lignotubers are the result of external infection, as suggested by Fletcher and Musson, (2) that they can be produced by artificial infection, as stated by Clayton O. Smith, (3) that they are produced by parasites, as stated by Vueillemin and Tubeuf and Smith. There is, however, some justification for the view that these authors have put forward. Tumours bearing a certain external resemblance to lignotubers may be produced on various eucalypts by the attacks of insects or fungi. They, however, differ in structure, are irregularly situated; persist indefinitely, and are not a constant feature of the development as are lignotubers. *E. rostrata* produces normally a pair of lignotubers, but Pl. X., Fig. C, shows two specimens with insect galls somewhat resembling lignotubers externally but differing in structure; devoid of food materials, and never becoming part of the normal tissues of the plant.

All the evidence points to the conclusion that the lignotubers are perfectly normal growths, which serve as embryonic storage organs for reserve food materials, and they represent admirable instances of the adaptive modifications of seedling eucalypts to their special conditions of life. They contain stores of food materials which enable the seedlings to tide over unfavourable periods until they are established with their root systems well into the subsoil. After this period is over there is less danger of the seedling suffering from drought, and the lignotubers merge gradually into the stem and disappear. Species inhabiting regions not liable to drought do not develop lignotubers, while their development is greatest in the species inhabiting the regions of the most uncertain climate where the necessity

for them is apparent. In these situations the seedlings persist through a long hot dry summer in a few inches of soil on the top of a rocky bed. In many such cases once the seedling has developed a lignotuber it may survive two or three unfavourable periods which kill down the young seedling to the base without affecting the more resistant lignotubers which send out new shoots until its food materials are exhausted.

This work was carried out in the Botanical Department of the University of Melbourne, and I wish to thank Professor Ewart for much helpful criticism. I am greatly indebted to numerous friends who helped by gifts of material, particularly Mr. Laidlaw, the Government Botanist, for supplies of seedlings, Messrs. G. Brunning and Sons for supplies of seedlings, and the use of their nursery stock for observation purposes, Professor Lawson, Mr. J. H. Maiden, F.R.S.; Mr. Kessel, Conservator of Forests, Western Australia; and Mr. Rodway, Government



TEXT FIGURE 7.

Botanist of Tasmania, for supplies of seed. Assistance in this direction was also given by Dr. Rogers, Mr. F. Baker, Mr. Russell Grimwade, Messrs. F. H. Brunning Pty. Ltd., and the Victorian Forests Commission. In addition I have to thank Professor Osborn for forwarding me some references to the literature, and Professor Laby and Dr. Bull for the use of the facilities of their departments.

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EXPLANATION OF PLATES.

PLATE X.

Fig. A.—*E. melliodora*, thirteen months old; 1, seedling with lobulated lignotuber with main stem carrying on the growth; 2 and 3, seedlings which have lost the main stem, the growth being carried on by secondary shoots from the lignotubers; S, main stem; M, root encircled by the lignotubers; B, root about to be encircled.

Fig. B.—*E. polyanthemos*, nineteen months old. 1, showing lignotubers resulting from the fusion of many pairs, the main stem lost, growth being carried on by secondary shoots; 2, twenty-three months old, nine weeks after the loss of the main stem; a, lignotubers developing on the secondary shoots, b and c.

Fig. C.—Two specimens of *E. rostrata*, bearing irregularly developed insect galls resembling lignotubers externally.

Fig. D.—*E. numerosa*, showing shoots from a stump bearing lignotubers; a, rotting stump, due to the attack of *Armillaria*; b, living strand of wood; c, lignotubers developing on the young shoots.

Fig. E.—*E. globulus* var. *St. Johnii*, twelve months old, showing lignotubers; a, which have just commenced to fuse; m, an unpaired lignotuber on the hypocotyl below the cotyledons.

Fig. F.—*E. Maidenii*, twenty-one months old, showing well developed secondary roots, r.

Fig. G.—*E. globulus* var. *St. Johnii*, showing lignotubers commencing to merge into the stems; a, secondary shoot arising from the lignotubers.

Fig. H.—*E. hemiphloia* var. *microcarpa*, showing well marked lignotubers, persisting at the base of the mature tree.



Fig. H

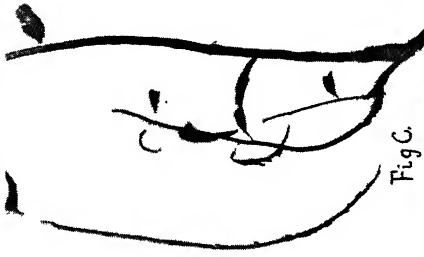


Fig. C.



Fig. G

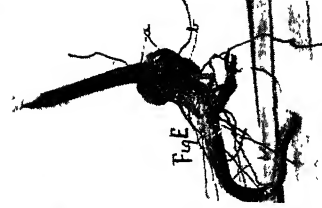
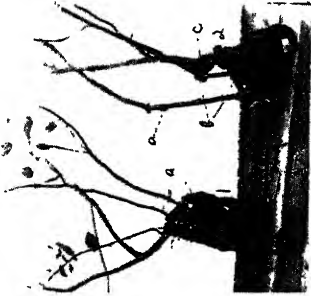


Fig. E



Fig. F

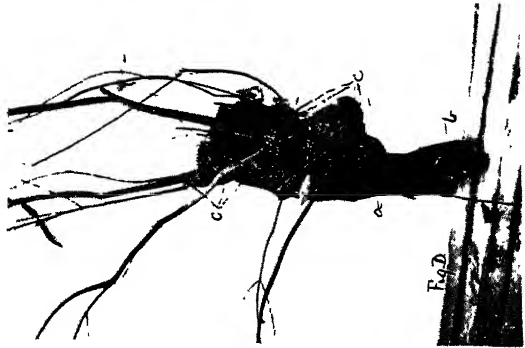


Fig. D



Fig. B

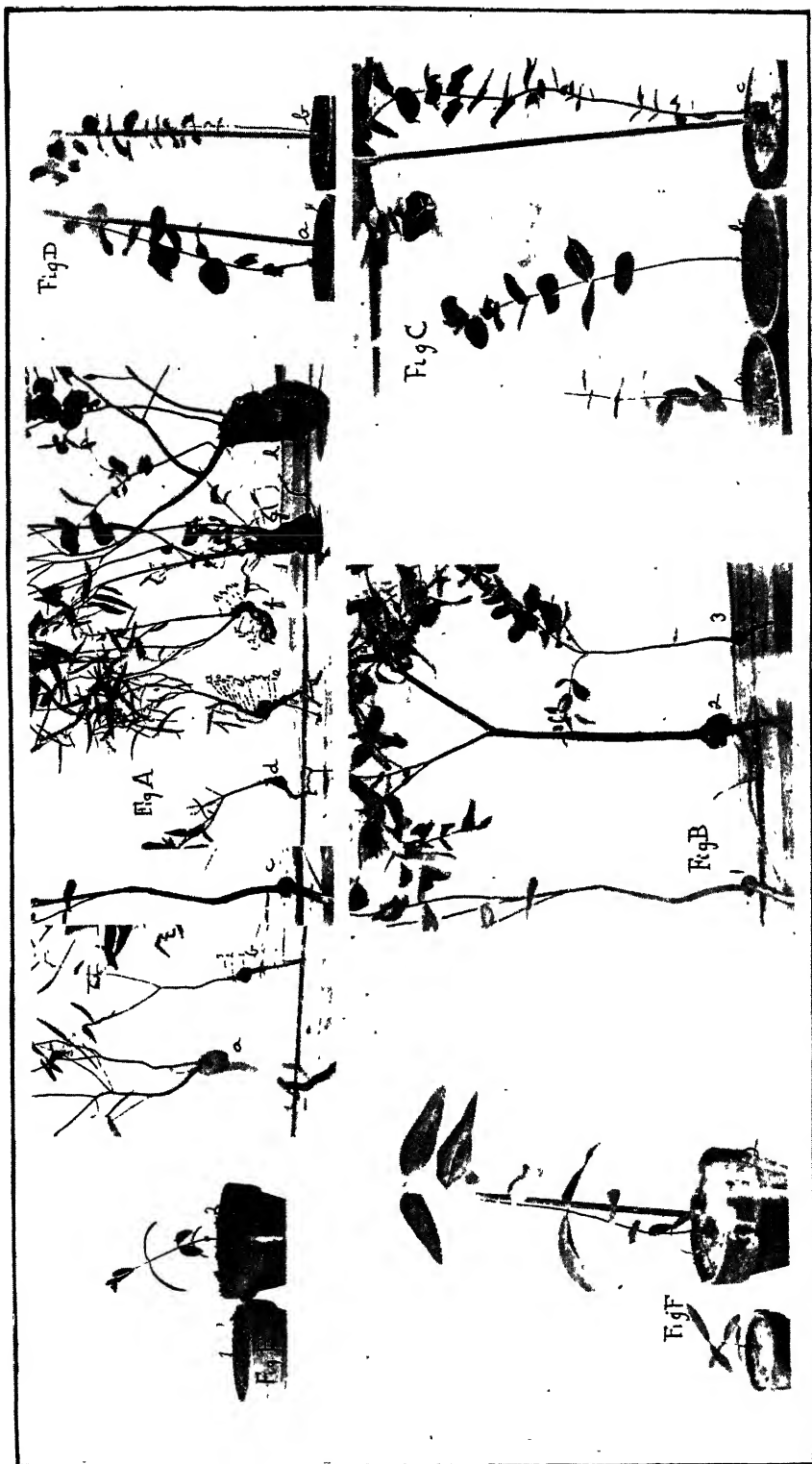


PLATE XI.

- Fig. A.—*E. numerosa*, showing stages in the development of the lignotubers; a, nine months old, with a single fused pair of lignotubers; b, five months old, with two pairs and an unpaired lignotuber, 1-3; c, four months old, grown in the shade, before fusion of the first pair of lignotubers; d, five months old, fusion in the vertical direction commencing; e, six months old, with twelve pairs of lignotubers, 1-12; f, seven months old, with nine pairs fusing in the vertical direction; g, eleven months old, fusion almost complete, the main stem lost, growth being carried on by secondary shoots; h, eighteen months old, fusion complete, main stem lost, growth being carried by secondary shoots.
- Fig. B.—*E. globulus* var. *St. Johnii*, eleven months old, grown in the shade before fusion of the single pair of lignotubers; 2, sixteen months old, with single pair of lignotubers; 3, eleven months old, grown in intense insolation.
- Fig. C.—*E. elaeophora*, seven months old, grown in ordinary potting soil; a, the control; b, watered at intervals for six months with a solution of potassium nitrate, 1 in 10,000; c, watered with a similar solution of calcium superphosphate.
- Fig. D.—*E. elaeophora*, five months old; a, grown in full sunlight, showing well developed lignotubers and large leaf area; b, grown shaded by frosted glass, taller, with a smaller leaf area than a, and the lignotubers just commencing to develop.
- Fig. E.—*E. coriacea*, five months old; 1, had portion of the radicle removed when pricked off; 2, a normal plant.
- Fig. F.—*E. coriacea*, the same seedlings as Fig. E, when eleven months old.

ART. VI.—*Investigation of Waters and Saline Materials
from Lake Eyre and District (Central Australia).*

By A. S. FITZPATRICK, M.Sc., and H. W. STRONG, M.Sc.

(Communicated by Professor A. C. D. Rivett.)

[Received 8th June, 1924.]

In July and August of 1922, a party, led by Mr. G. H. Halligan, F.G.S., of Launceston, Tas., journeyed to Marree, Northern South Australia, with the object of engaging upon the scientific investigation of the fauna and flora and geographical features of Lake Eyre and the district immediately surrounding it. The chief aim of the party was to launch a boat on North Lake Eyre itself, and then explore the area of open water which had been charted in an aeroplane survey, undertaken by Mr. Halligan, in the previous March.

Unfortunately, the project had to be abandoned owing to the recession of the water quite beyond the range of vision (about eight miles), leaving extensive mud flats, which it was impossible to cross at the only point where it had been thought feasible to launch the boat, namely, at the mouth of the Frome River, in the extreme south-eastern corner of the lake.

However, the party was able to get to the water in South Lake Eyre, and the samples were there collected. The analyses of these are given in this paper, together with those of other samples of material collected in the locality.

As a preliminary to this work, especially for the water analyses, it was deemed advisable to develop suitable analytical processes by working on samples of ordinary sea water. As a guide to the work, a series of analyses performed by Dittmar on the sea water samples collected by the "Challenger Expedition" and reported in "Challenger Reports," Vol. I., was consulted.

The investigations involved in this development and standardisation of methods, and the actual methods adopted are as follow:—

Analytical Procedure.

Chlorine.—The usual gravimetric procedure was followed. This gives chlorine and bromine combined.

Bromine.—A method of fractional precipitation with silver nitrate was employed. Chlorine was passed over the mixed silver chloride and bromide, and the bromide determined by the loss in weight due to the displacement of bromine by chlorine.

A litre of water was measured out, and about 30 c. cm. of 5N nitric acid was added. Then 1/25 of the amount of silver nitrate solution (220 c. cm. of N/10) necessary to precipitate all the halogen was added, and the mixture well shaken in a Winchester quart bottle. The precipitate was settled over-night. After de-

cantation, a further fractional precipitation was carried out with the same amount of silver nitrate. All the bromine was precipitated by the two fractionations. The washed precipitates were dried and placed in a porcelain boat in a small combustion furnace, the boat being contained in a small piece of combustion tubing about six inches long. Here the mixed halides were fused while a slow current of dry chlorine was passed over them, being led into the tube through a short piece of tube loosely ground into the end. Before passing chlorine, constant weight in a dry air current was obtained. Then constant weight was obtained in a dry chlorine current, the tube being finally washed out with air. In weighing, the boat was not disturbed, but was weighed in, and together with, the short combustion tube.

Results.

(For Ordinary Sea Water.)

No. of expt.	Weight of tube and boat after passing air.	Weight of tube and boat after passing chlorine.	Mean loss of weight.	Bromine per 100 g. of total salts.
A 2nd ppt. ..	48.5588	48.5534	0.0054	—
A 1st ppt. ..	48.6790	48.6525	0.0265	0.1586
B 2nd ppt. ..	46.8082	46.8033	0.0049	—
B 1st ppt. ..	46.7872	46.7548	0.0324	0.1854

The values given in column 5 were calculated from the losses in weight given in column 4, together with the following data:—

Weight of one litre of water - - - - 1025.6g.

Weight of total salts per 100g. of water - 3.53g.

Though done on samples collected at different times, these results showed too great a variation in the bromine content. They could not, however, be repeated, as the large volumes required for the determinations had used all of the samples available. Accordingly, some artificial sea waters were made up by dissolving 30g. of pure fused sodium chloride, and a definite weight (about 60 m.gm.) of bromine in the form of potassium bromide in one litre of distilled water. The sodium chloride was tested colorimetrically, and gave no indication of bromine. A blank determination was also run, using 30g. of sodium chloride, but no bromide.

No.	Air.	Chlorine.	Loss.
Blank ..	46.8732	46.8730	Inappreciable.
A 1st ppt. ..	40.0448	40.0153	0.0295 - Equiv. to 0.0531 g. Br.
A 2nd ppt. ..	39.5723	39.5692	0.0031 - " " 0.0056 "
B 1st ppt. ..	37.9738	37.9438	0.0300 - " " 0.0540 "
B 2nd ppt. ..	41.5844	Tube Cracked.	

Thus for experiment A, of 0.0605g. of bromine distributed through the solution (one litre) 0.0587g. were determined by the

method. For experiment B (using the second precipitate value of A, everything being under standard conditions) of 0.0590g. of bromine added 0.0596 were determined.

Thus, with careful manipulation, good results could be obtained.

Total Salts in Solution.—The first evaporations tried showed the necessity for weighing in a closed vessel owing to the hygroscopic character of the residue. Evaporations finished in the air even at 115-120°C. gave results too high, owing to non-expulsion of water of crystallisation.

e.g., A 3.64% B 3.73%

Before becoming constant, A underwent a considerable number of dryings more than B. This leads to hydrolysis, so that the dried residues have to be dissolved in water and titrated for alkalinity with N/10 hydrochloric acid, and N/10 caustic soda, using methyl orange as indicator, and a form of "zig-zag" titration. This is more or less straightforward, but is tedious, and so are the subsequent calculations.

Two residues were transferred to porcelain crucibles, and heated over Meker burners to expel water of crystallisation, as mentioned above. These were rendered useless by volatilisation of some of the residue.

Evaporation in a current of dry hydrogen chloride gas (suggested by Prof. Rivett) was then undertaken. This proved very satisfactory, being easy in operation, and giving constant weights readily. No further corrections had to be made, as hydrolysis was entirely prevented, and the correction for conversion of carbonate into chloride was quite negligible. The results obtained were in good agreement, viz., 3.53% and 3.51%.

Further evaporations of 20 c. cm. samples in silica crucibles were undertaken. They were taken almost to dryness in the air oven at 115°C., heated just to a pink colour over a Bunsen burner for about five minutes, then cooled in a desiccator and the crucible weighed with the lid on. The residue was then removed and alkalinity determined by titration and calculation as before. The actual experimental work was, for the evaporation, about the same as in the case of the hydrochloric acid evaporation—if anything, somewhat less; but, after this, came the "zig-zag" titrations, and then the necessary calculations. These again proved tedious. The results were in fair agreement with those of the hydrochloric acid evaporation, being

3.53% and 3.56%.

The evaporation in a current of dry hydrochloric acid gas is, therefore, the best method for this determination.

Sulphate, Lime and Magnesia.—These were determined by the usual gravimetric methods as barium sulphate, calcium oxide (from oxalate), and magnesium pyrophosphate, respectively.

Total Bases as Sulphates.—Twenty c. cm. of water were weighed into a silica crucible. 3 c. cm. of dilute sulphuric acid

(5N) were added, and the whole evaporated to dryness. Constant weight was obtained after alternate additions of more acid followed by evaporation and heating over a Meker burner for about fifteen minutes.

Carbonic Acid.—(By vacuum baryta method.) 300 g. of the sea-water were placed in a 700 c. cm. round-bottomed flask with side tube. In this flask the carbon dioxide was liberated by the addition of hydrochloric acid. The remainder of the apparatus, and the method of procedure, were similar to those given by G. Ampt., J. Soc. Chem. Ind. of Victoria, 1923, p. 1006. Dissolved gases in the water reduce the vacuum in the apparatus, but not sufficiently to impede the diffusion of the carbon dioxide into the absorption flask containing barium hydroxide.

Alkalis.—The mixed chlorides of sodium and potassium were obtained by the usual method (as given, for instance, in Mellor's "Quantitative Inorganic Analysis"). In these the potassium was then determined by precipitation as platinichloride.

Spectroscopic tests were carried out for the rarer alkali metals, a chart being prepared on which spectrum lines of known wavelengths, from known metals, were plotted against spectrometer readings.

Lake Eyre South Waters.

Analysis of Sample No. 1, collected in water 2 to 2½ inches deep, 100 yards from the shore.

Specific gravity (20° C)	..	1.0581			
Hydrogen ion concentration					
(by polychrome indicator)	..	10 ^{-7.5}			
Total Salts	..	7.72	g. per 100 g. of water.		
Total bases as sulphates	..	119.1	g. per 100 g. of total salts.		
Calcium oxide	..	3.18	"	"	"
Magnesium oxide	..	0.66	"	"	"
Sodium oxide	..	47.84	"	"	"
Potassium oxide	..	0.476	"	"	"
Sulphur trioxide	..	5.31	"	"	"
Carbon dioxide	..	0.112	"	"	"
Chlorine	..	54.03	"	"	"
Chlorine minus basic oxygen	..	41.86	"	"	"
Bromine	..	0.015	"	"	"
<hr/>					
Total bases as sulphates	..	120.1	Calculated.		
"	"	119.1	Found.		

Summation of Constituents.			Equivalents		
CaO	..	3.18	-		
MgO	..	0.66	-		
Na ₂ O	..	47.84	-		
K ₂ O	..	0.476	-		
SO ₃	..	5.31	-		
CO ₂	..	0.112	-		
Cl-(O)	..	41.86	-		
Br	..	0.015	-		
<hr/>			<hr/>		
Total	..	99.46	-	1.699	- 1.860
Lithium, rubidium and caesium were proved by spectroscopic tests to be absent.					

Sample No. 2, collected in water 3 inches deep, 200 yards from the shore.

Specific gravity (20° C) ..	1.0660				
Hydrogen ion concentration (by polychrome indicator)	10 ^{-7.5}				
Total salts	8.68	g. per 100 g. of water.			
Total bases as sulphates ..	118.40	g. per 100 g. of total salts.			
Calcium oxide	2.66	"	"	"	"
Magnesium oxide	0.67	"	"	"	"
Sodium oxide	47.84	"	"	"	"
Potassium oxide	0.495	"	"	"	"
Sulphur trioxide	5.09	"	"	"	"
Carbon dioxide	0.110	"	"	"	"
Chlorine	55.74	"	"	"	"
Chlorine minus basic oxygen	43.18	"	"	"	"
Bromine	0.018	"	"	"	"
<hr/>					
Total bases as sulphates ..	118.97	Calculated.			
" " " "	118.40	Found.			

Summation of Constituents		Equivalents.			
CaO ..	2.66	-			
MgO ..	0.67	-			
NaO ..	47.84	-			
K ₂ O ..	0.495	-			
SO ₃ ..	5.09	-			
CO ₂ ..	0.110	-			
Cl-(O) ..	43.18	-			
Br ..	0.018	-			
<hr/>		<hr/>			
Total ..	100.06	-	1.670	-	1.685

Lithium, rubidium and caesium were proved by spectroscopic tests to be absent.

Lake Eyre Materials.

Sample No. 1. Efflorescent material, obtained from an old well shaft sunk in shale.

Water soluble ..	89.50 %		
Moisture ..	47.07		
Calcium oxide ..	0.73		
Magnesium oxide ..	0.31		
Sodium oxide ..	17.84	Hydrogen ion concentration (by polychrome indicator)	
Potassium oxide ..	0.34		
Sulphur trioxide ..	23.00		
Chlorine ..	1.00		
Chlorine minus basic oxygen ..	0.78		
Carbon dioxide ..	0.18		

Sum of soluble constituents 90.25

The chief constituents, soda and sulphuric acid, are present in equivalent proportions, and it might be stated that of the total water-soluble matter 93% consists of sodium sulphate. This is interesting in view of the fact that the district abounds in gypsum (CaSO₄·2H₂O) and in salt (NaCl).

Sample No. 8. Saline scum from the lake margin.

Water soluble	..	..	..	..	84.82 %
Moisture	..	..	..	..	7.45
Calcium oxide	..	..	..	..	1.70
Magnesium oxide	..	..	..	..	0.94
Sodium oxide	..	..	..	..	36.80
Potassium oxide	..	..	..	..	0.20
Sulphur trioxide	..	..	..	..	6.96
Carbon dioxide	..	..	..	..	0.092
Chlorine	..	..	..	..	39.66
Chlorine minus basic oxygen	..	..	..	..	30.70
Sum of soluble constituents	..	..	..	..	<u>84.84</u>

ART VII.—*New or Little-known Fossils in the National Museum.* Part XXVIII.—*Some Silurian Rugose Corals.*

By FREDK. CHAPMAN, A.L.S.

(Palaeontologist to the National Museum, Melbourne.)

(With Plates XII.-XV.)

[Read 12th June, 1924.]

Introduction.

During the past few years several new or interesting examples of rugose corals have been acquired, mainly through the generosity of the discoverers, for the Museum collection. These, together with several hitherto obscure generic types in the old Geological Survey collection made by the late Dr. Alfred Selwyn, formed, it was thought, a sufficiently important collection to describe or otherwise elucidate at the present time.

No doubt shortcomings will be found, in the incompleteness of the comparisons made, by specialists elsewhere, but these may be partly excused by the lack of literature, since some of the more essential works on Palaeozoic corals, are apparently not included in any of the Melbourne or even Australian libraries.

It is here interesting to notice the similarity between European and American types of certain rugose corals and those of the Australian forms, and even in some cases the conspecific relationship which can be established.

The confirmation of Nicholson and Etheridge's remarks on the genus *Lindstroemia* is clearly seen in the diagnoses of the Victorian species, which, although so poorly preserved as fossils in the impure limestone, show all the essentials of the internal and external characters of the corallum.

Synopsis of Species.

The following genera and species of rugose corals are here described or discussed:—

Name.	Locality.	Age.
<i>Lindstroemia yeringiae</i> , sp. nov.	Yering District, Upper Yarra; Ruddock's Quarry, Lilydale; nr. Seville, east of Lily- dale.	Silurian (Yeringian)
" <i>parva</i> , sp. nov.	Yan Yean; Merri Creek, Kalkallo.	Silurian (Melbournian)
" <i>ampla</i> , sp. nov.	Cemetery Hill Road, Whittlesea.	Silurian

„	<i>conspicua</i> , sp. nov.	South Yarra; Moonee Ponds Creek.	Silurian (Melbournian)
„	<i>scalaris</i> , sp. nov.	Wandong; Glenburnie Road, Whittealesea.	Silurian
		Glenburnie Road, Whittealesea; Wandong.	
		Camberwell.	Silurian (Melbournian)
<i>Cyathophyllum</i>	<i>crewelli</i> , sp. nov.	Cave Hill, Lilydale.	Silurian (Yeringian)
„	<i>subcaespitosum</i> , sp. nov.	Cave Hill, Lilydale.	Silurian (Yeringian)
<i>Spongophyllum</i>	<i>stevensi</i> , sp. nov.	Cave Hill, Lilydale.	Silurian
„	<i>shearsbii</i> , sp. nov.	Hatton's Corner, Yass, N.S.W.	Silurian
„	<i>bipartita</i> , fil. sp.	Eth. Hatton's Corner, Yass, N.S.W.	Silurian
<i>Columnaria</i>	<i>fleming-tonensis</i> , sp. nov.	Moonee Ponds Creek, near Melbourne.	Silurian (Melbournian)

Description of Species.

Sub-class TETRACORALLA.

Fam. CYATHAXONIIDAE.

Sub-fam. LINDSTROEMIINAE, Chapman.

{Corals of the Cyathaxonid type, but calices with dissepiments.}

Genus *Lindstroemia*¹, Nicholson and Thomson, 1876.

Observations on the Genus.—In the Proceedings of the Royal Society of Edinburgh for 1876, Vol. IX., No. 95, p. 150, Dr. Alleyne Nicholson and Mr. James Thomson proposed the name *Lindströmia* for a new genus of small Palaeozoic corals “in which the corallum is simple and conical, with an extremely deep calice. The septa are well developed and meet in the centre of the visceral chamber, where they coalesce to a greater or less extent, and form a strong, twisted pseudo-columella, which projects into the floor of the calice, and occupies a large portion of the entire visceral chamber. There are no tabulae, but the septa are furnished with more or less strongly developed dissepiments, which, however, are remote and do not give rise to any vesicular zone. The species *L. columnaris* was described from the Devonian rocks of North America, and it was mentioned that the authors were in possession of other forms of the genus, still undescribed, from the Carboniferous rocks of Scotland.”

This paper was, unfortunately, only published in abstract, so that even the selected genotype, *L. columnaris*, was not described.

Later on, however, in 1880 (“Silurian Fossils of the Girvan District in Ayrshire,” Vol. I., p. 84, Figs. 4b, b¹),” Dr. Nicholson,

1.—This spelling is here adopted with “oe,” as an extension of the modified “o”; cf. *Roemeraster* and *roemeri*.

in conjunction with R. Etheridge, junr., published figures of *Lindstroemia columnaris*, Nich. and Thoms., so that the actual structure of the genotype is known from the drawings. Those authors again refer, at some length, to the characters of *Lindstroemia* as a genus, and passing over the "selected" genotype², they refer to several species as typical of the genus, the first to be enumerated being Lindström's "*Cyathaxonia*" *dalmani* (loc. cit., p. 81).

This form, together with "*Cyathaxonia*" *siluriensis*, McCoy, and one of McCoy's "*Petraia*"—viz., *subduplicata*, and a Girvan species, *L. laevis*, are there described.

Since Nicholson and Etheridge minutely describe the generic characters of *Lindstroemia* in their "Girvan Fossils," characters which are quite comparable with those of some Australian Silurian examples, I have no hesitation in accepting the generic name, although no genotype is there specifically mentioned or even indicated.

Generic Characters of *Lindstroemia*—after Nicholson and Etheridge junr.³

"Corallum simple, conical or turbinate, the epitheca complete, with well-marked longitudinal ridges, fine encircling striae, and low annulations of growth. Septa well developed, lamellar, equally developed or of two sizes, united inferiorly in the axis of the visceral chamber, and augmented by a secondary deposit of sclerenchyma, so as to form a comparatively enormous columella, which projects into the floor of the calice. The lower portion of the visceral chamber often more or less completely filled up by the deposition within it of solid sclerenchyma. Interseptal loculi, usually crossed by a few strong and remote dissepiments; and the upper portion of the visceral chamber not uncommonly traversed by thick transverse plates of the nature of tabulae, though at other times these are not recognisable, or at any rate have not been clearly made out."

As already referred to, Nicholson and Thomson's MS. name of *L. columnaris* has since been figured and briefly described in the explanation to figure given by Nicholson and Etheridge junr., so that the genotype, which, according to Nicholson, one of the authors, still retains that status, remains good, but should now be referred to the authorities, Nicholson and Etheridge junr. This point should not be obscure, since Nicholson and Thomson had already selected a form which was described subsequently.

It may be noticed, in passing, that in the original description based on the still undescribed but figured *L. columnaris*, Nicholson and Thomson state that "There we have no tabulae" (loc.

2.—Cf. "Girvan Fossils," 1880, p. 81.—"The genus *Lindströmia* was founded by one of the present writers and Mr. James Thomson, for the reception of certain small corals from the Devonian formation of North America, the specific description of which is unpublished."

3.—"Girvan Fossils," 1880, p. 80.

cit. 1876, p. 150); this statement is emended by Nicholson and Etheridge junr. (loc. cit., 1880, p. 83), who say, "Upon the whole, however, we think that the presence of ill-developed tabulae may be regarded as the rule in the genus *Lindstroemia*."

Note on the Relationship of the Genus *Lindstroemia*.—The genus *Lindstroemia* is now known from beds as old as the Middle Ordovician (Black River Series) of Kentucky, *L. whiteavesi*, Foerste); from the Upper Ordovician and Lower Silurian of Scotland and England (*L. subduplicata*, McCoy sp.); from the Upper Ordovician of Girvan, Scotland (*L. laevis*, Nicholson and Etheridge fil.); from the Upper Silurian of Gotland (*L. dalmani*, Edwards and Haime sp.); and from the Devonian of North America (*L. columnaris*, Nicholson and Thomson).

From *Cyathaxonia*, *Lindstroemia* differs in having a columella derived from the septal elements to which it is connected by dissepiments; whereas in the cyathaxonid type the columella, excepting at the earliest stage, is essential, that is, possessing a distinct character apart from the septal development.⁴

Towards *Zaphrentis* there is a strong affinity, in the case of *Lindstroemia ampla*, in the development of cardinal and counter septa, although no fossula is distinctly seen.

LINDSTROEMIA YERINGAE, sp. nov.

(Plate XII., Figs. 1a-f; Pl. V., Figs. 20, 21.)

Description.—Corallum of moderate size, typically elongate-conical; straight or slightly curved. Exterior showing vertically costate epitheca, the striae having an interseptal relationship. Straightness of sides of corallum somewhat interrupted by growth stages, representing the thickening of the edges of successive calicular borders. The transverse sectional outline of the calice shows this coral to be of somewhat irregular contour, very few examples being truly circular in section. Several examples are almost elliptical, whilst others are slightly compressed at various angles.

A horizontal section across the top of the calice shows a series of 45 short spinose-septa. at first sight of about equal length, projecting only about $\frac{1}{5}$ the distance to centre; on closer inspection these septa are seen to be alternately long and short, especially in the earlier part of the calice. where they are short and thick, and longer with spinose ends.

A horizontal section of the calice at circ. 6 mm. from the base shows the septa to extend nearly to the centre, where they meet to form a solid pillar of coenenchyma, in which the partially resorbed septal plates are still visible.

An interesting feature of the septal structure in these examples is brought out in section owing to the peculiar preservation of

4.—Cf. Robinson, W.I. The Relationship of the Tetracoralla to the Hexacoralla. Trans. Connecticut Acad. Arts and Sciences, Vol. XXI., 1917, p. 189, et. seq.

the corallum in an impure limestone; the interseptal spaces, coincident with the epithecal costae, are filled with ochreous mud and in sections appear as true septa, but are merely negative structures.

A vertically and medially sliced specimen (paratype) shows the basal filling of the cup to extend, in this example, for two-thirds the height of the calicular cavity. In another paratype, similarly sliced, definite dissepiments are seen between the wall and the basal columella.

Dimensions of Holotype.—Length of corallum, 27 mm. Width of calice, at 12.5 mm.

Observations.—The nearest related species to the above seems to be "*Petraia*" *subduplicata* of McCoy's⁵, which Nicholson and Etheridge junr. have refigured and placed under *Lindstroemia*⁶. In McCoy's species, however, the corallum is often shorter, and it is broader at the distal and more acuminate at the proximal, whilst the columella is more massive. The epithecal striae are finer than in *L. subduplicata*.

L. subduplicata is a Caradocian (Upper Ordovician) and Upper Llandovery (Older Silurian) fossil in Ayrshire (Scotland), and Denbighshire (Wales).

Occurrence.—From the Silurian (Yeringian) mudstones and impure limestone of the Yering District, Upper Yarra (G. S. V. coll.). Also Ruddock's Quarry, Lilydale (coll. F. C.); and near Seville, east of Lilydale (coll. F. C.).

LINDSTROEMIA PARVA, sp. nov.

(Plate XII., Figs. 2, 3.)

Description.—Corallum small, elongate-cylindrical to short conical, with a slight curvature. Septa about 15 to 20. Epitheca strongly striated and apparently slightly spiny. Growth stages or rejuvenescent periods well marked. Columella evidently short.

Dimensions.—Length of Holotype, 9.5 mm. Width at calicular end, 5 mm.

Observations.—The species is much smaller than the preceding (*L. yeringae*), and the corallum is more regularly cylindrical. The septa are less numerous.

L. parva seems to have its analogue in *Lindstroemia laevis*, Nich. and Eth. junr.⁷, of Upper Llandovery age, from Girvan, Scotland, but the latter is more turbinate.

Occurrence.—Silurian (Melbournian). In the grey mudstone of Yan Yean, G. S. V. coll., Bb 13; and in beds of similar age, in pale grey mudstone, Merri Creek, Kalkallo, sects. 2 and 3, G. S. V. coll., Bb 3.

5.—McCoy, 1850. Ann. and Mag. Nat. Hist., ser. 2, Vol. VI., p. 279. Idem, 1852, Pal. Foss., p. 40, pl. I., fig. 26.

6.—Silurian Fossils of the Girvan District, in Ayrshire, 1880, Vol. I., p. 86, woodcut on p. 84, fig. 4: pl. VI., figs. 2-2f.

7.—Sil. Foss. Girv. Distr., 1880, p. 90, pl. VI., figs. 4, 4e.

LINDSTROEMIA AMPLA, sp. nov.

(Pl. XI., Figs 4a-c; Pl. XV., Fig. 22.)

Description.—Corallum of fairly large size, short conical or turbinate, with a slight curvature. Major septa about 22 to 30, with short septa intercalated. When a wax squeeze is taken from the well-preserved casts, in which condition this coral often occurs, the septa are seen to be quite narrow to the base and their edges slightly spinulose. The columellar axis is seen as a large low mound extending over nearly the whole of the cavity. Where the septa meet in the centre, this species exhibits a marked polarity in the mesenteries, but not to so great an extent as in *Zaphrentis* and *Streptelasma*, and the shorter septa are twisted where they adjoin the cardinal and counter septa. Although the shape of the coral is turbinate and pointed, the cast, owing to the columellar mound, always appears truncated at the base, terminating in a sharp point.

A median vertical section of a paratype shows the calicular wall to be of moderate thickness (circ. 1.5 mm.); the base is filled to a height of 9 mm., with partially fused septa connected by irregular dissepiments. A transverse section across the top of the calice (rim) shows the septa there to be represented by mere spines projecting from a thickened epithecal base, and not longer than 2 mm. in length.

Dimensions.—Length of Holotype, 29.5 mm. Width at calicular opening, 22 mm. A gerontic form measures 46 mm. long and 39 mm. at opening of cup.

Occurrence.—Silurian (Yeringian). Holotype and others; Yering. Upper Yarra, G. S. V. coll., B23. Junction of Woori Yallock and Yarra, G. S. V. coll., B23. Griffith's Kiln, Mansfield, Vic., E. O. Thiele coll. Watson's Creek, G. S. V. coll., B22. Deep Creek, near Watson's Creek, G. S. V. coll. B20.

Silurian. Cemetery Hill Road, Whittlesea, W. J. Parr coll.

LINDSTROEMIA CONSPICUA, sp. nov.

(Pl. XII., Figs. 5-7, 8a, b; Pl. XV., Fig. 23.)

Description of Holotype (cast).—Corallum moderately large, regularly conical, rather short and broad. Principal septa about 25 at edge of corallum; about half the number at the base, where they are differentiated by two opposing septa, but not twisted to so marked an extent as in the preceding *L. ampla*.

A paratype from the same locality of South Yarra is partly in the form of a cast in fine siliceous mudstone, but retains a portion of the epithecal wall of the corallum near the outer rim. The basal portion shows 26 septa, which increase to twice the number at a later stage. The epithecal wall is finely granulate externally, and bears a definite sulcate ridge corresponding with the mesen-

tery beneath, now filled with matrix. The septa are shown as linear slits in the cast.

A wax squeeze of this paratype shows the base to be partially filled with a low mound of fused septa occupying about one-half the diameter of the cavity. The septa entirely down to the base are short and thin, and the arrangement of the septa indicates bilateral symmetry. The form of this paratype is broadly conical with the distal edge somewhat expanded.

Dimensions.—Length, 26 mm. Width, 23·5 mm.

Length of paratype, circ. 21 mm. Width of cup at base, 18·5 mm. Width of cup at base, from a squeeze, 12·5 mm. Diameter of columella, 6 mm.

Observations.—The number of septa in this species closely corresponds to that of *L. ampla*, but the shape of the corallum is quite distinct in being shorter and wider, and its conical form is more circular in section. In *L. ampla* the progressive growth is marked by an undulating epithecal wall, whilst in *L. conspicua* the wall is more regular and typically flat-surfaced.

Among British examples of what I conceive to be *Lindstroemia*, one may cite Phillips' Silurian form, "*Turbinolopsis elongata*" as related to *L. conspicua*, but it differs substantially in having a more lengthened corallum.

Occurrence.—Silurian (Melbournian); common in the white siliceous and black mudstones of South Yarra, coll. F. P. Spry. Also at Moonee Ponds Creek; J. F. Bailey, coll.

Silurian. Wandong, and Glenburnie Road, Whittlesea; J. T. Jutson coll.

LINDSTROEMIA SCALARIS, sp. nov.

(Plate XII., Figs. 9, 10.)

Description of Holotype (cast in ferruginous sandstone).—Corallum, elongate-conical, expanded at the mouth. Rejuvenescent periods strongly marked by the collar-like rim of successive cups, amounting to three in the present specimen. Septa of the adult form about 36.

General form closest to *L. ampla*, but with a large number of septa and strong growth stages.

A wax squeeze of the base shows the columella to be inconspicuous and the cavity deep.

Dimensions.—Length of corallum, 16·5 mm. Width of cup, circ. 12 mm.

Observations.—An example from Wandong shows about 40 septa, and the hollow mould indicates a coral with an attenuated base. The Camberwell specimen is shorter in its longer axis, but shows the same strong growth stages.

8.—*Turbinolopsis* sp., Lonsdale. Silurian System, 1839, p. 693, Pl. XVI. bis, Fig. 6. *Turbinolopsis elongata*, Phillips Palaeozoic Fossils of Cornwall, Devon and West Somerset, 1841, p. 6, Pl. II., Fig. 6B.

Occurrence.—Silurian. Glenburnie Road, Whittlesea; coll. J. T. Jutson. Wandong; coll. F. P. Spry.

Silurian (Melbournian). Hawthorn Brick Quarry, Camberwell; coll. R. H. Annear.

Fam. CYATHOPHYLLIDAE.

Genus *Cyathophyllum*, Goldfuss.

CYATHOPHYLLUM CRESSWELLI⁹, sp. nov.

(Plate XIII., Figs. 11-14.)

Description.—Corallum large, simple in habit, of erect growth; in form cylindrical with parallel sides, tapering at the base. Calyx deep; septa numerous, about 72 in three cycles. A cardinal and counter septum are seen in one example (a paratype, transverse section), extending almost across the thecal cavity. Septa slightly undulose, thinning out towards the centre of the cup, with twisted ends. Dissepiments abundant in outer zone, obliquely set in herring-bone fashion, but sometimes curved. Tabulae of central area short, discontinuous, and breaking up the septal plates into more or less cubical areas. Dissepiments of outer zone, as seen in vertical section of corallum, somewhat curved or vesicular. Epithecal walls not thick, somewhat wrinkled.

Juvenile examples are common which measure about 1 inch or more in length and are consequently not cylindrical, but turbinoid.

Dimensions.—Type (vertically sliced co-types); length (probably incomplete), 66 mm.; diameter of calice, 29 mm.

Length of Paratype (incomplete), 76 mm.; diameter at either end, circ. 34 mm.

Observations.—This striking coral cannot be confused with a similarly large Silurian form from Victoria and New South Wales, viz., *C. shearsbii*, Süssmilch¹⁰ on account of its cylindrical habit of growth. In *C. shearsbii* the corallum is distinctly turbinate, and is strongly curved in the earlier part of the corallum; the epithecal wall is thicker and more rugose, and the dissepiments of the outer zone are distinctly convex, instead of straight or oblique.

In its cylindrical character the present species, *C. cresswelli*, resembles the English Silurian (Wenlock Shale) species, *C. angustum*, Lonsdale¹¹, from Lickey, in Worcestershire, as also in its numerous septa and short tabulae; but differs in the more restricted dissepimental outer zone.

9.—Named in recognition of the late Rev. A. W. Cresswell's enthusiastic collecting in the early history of the Lilydale Quarry.

10.—*Cyathophyllum shearsbii*, Etheridge, junr., MS., Rec. Austr. Mus., Vol. V., Pt. 5, 1904, p. 288 (footnote). Süssmilch, Geol. N.S. Wales, 1904, figure only, Fig. 14B, facing p. 44. Chapman, Rec. Geol. Surv. Vict. Vol. LV., Pt. 2, 1920, p. 183, Pl. XVIII., Fig. 7; Pl. XIX., Fig. 9.

11.—Lonsdale, in Murchison's Silurian System, 1839, p. 690. Pl. XVI., Fig. 9.

In external appearance *C. cresswelli* recalls Röminger's Silurian species, *C. houghtoni*¹², but is easily distinguished by its dissepimental tissue in the outer septal zone.

Occurrence.—Silurian (Yeringian). Cave Hill, Lilydale, Victoria. Holotype and a paratype collected by the Rev. A. W. Cresswell, M.A. Paratype (juvenile example) presented by R. H. Annear, Esq.

CYATHOPHYLLUM SUBCAESPITOSUM, sp. nov.

(Plate XIII., Figs. 15, 16a, b.)

Description.—Corallum compound or aggregated; corallites more or less crowded, sometimes impinging on one another, when they become irregularly polygonal, forming a loosely bundled mass. Corallites of medium size, circular, elliptical or subpolygonal, with thin epithelial wall. Septa about 60, almost meeting at the centre. Primary cycle of septa with blunt or thickened ends, the secondary and tertiary ones correspondingly much shorter and thinned at the extremities. Outer zone of dissepiments extending to about one-half the diameter of the corallites, densely crowded and distinctly marked off from the inner zone. Basal sections of the corallites show definite pali to be there developed, and a directive septum extends across the corallite.

Dimensions.—Type specimen of fasciculated corallites, 85 mm. across. Average diameter of corallites, 12 mm. Height of type specimen, showing incomplete length of corallites, 52 mm.

Observations.—This species is clearly related to the well-known Devonian coral, *Cyathophyllum caespitosum*, Goldfuss,¹³ of Devonshire and the Eifel. It differs in the more numerous septation; in the denser outer dissepimental zone; and in the more general contiguity of the corallites. The respective diameters are very similar.

Occurrence.—Silurian (Yeringian). Cave Hill, Lilydale, Victoria. Presented by the Rev. A. W. Cresswell, M.A., 6.02.

Genus *Spongophyllum*, Edwards and Haime.

The corals ascribed to this genus are practically confined to the Devonian rocks in other parts of the world.

In *Spongophyllum* the corallum is massive, compound and the corallites prismatic. The latter are united by their external walls. Internal walls and columella absent. Septa numerous, thin and merged into vesicular tissue, which is abundant. Centre of vesicular cavity tabulate.

12.—Geol. Surv. Michigan, Vol. III., Pt. II., Palaeozoic Corals, 1876, p. 104, Pl. XXXVI.

13.—Petrefacta Germaniae, Vol. I., 1826, p. 60, Pl. XIX, Fig. 2. Edwards and Haime, Mon. Pal. Soc., Vol. VII., 1853, p. 229, Pl. LI., Figs. 2, 2a, b. Milne Edwards, Histoire Naturelle des Coralliaires, Paris, 1860, p. 382, No. 37.

SPONGOPHYLLUM STEVENSI, sp. nov.

(Plate XIV., Figs. 17a, b; Pl. XV., Figs. 24, 27.)

Description.—Corallum compound, massive, moderately large, mushroom-shaped or sub-flabellate. Corallites polygonal, chiefly hexagonal, occasionally pentagonal. Mural walls defined as a sharp, thin line. Septa numbering about 30, alternate in length; short, stout at base and sharply pointed, extending into the thecal cavity for about one-half the diameter to the centre. Central area divided by the dissepimental tissue of the vesicular growth. In longitudinal section the central cavity is seen to be feebly tabulate, otherwise occupied by vesicular dissepiments. Vertical sections tangential to the wall of the corallites show the rigid and straight septal bars, divided by very thin tabulae.

Dimensions.—Corallum (almost complete) measuring from point of attachment to outer growth zone, 16.5 cm. Greatest width, circ. 18.7 cm. Greatest depth at growing surface, 6.8 cm. Average diameter of corallites, 6 mm.

Observations.—The above species closely approaches *Spongophyllum sedgwicki*, Edwards and Haime¹⁴, of the Devonian of Torquay, England, in the general characters of the corallites, but shows the following differences:—

In *S. stevensi* the corallites are more regular in size.

They are slightly larger.

The septa are stouter basally.

Thecal wall thinner.

Vesicular tissue more irregular in horizontal section.

Tabulae less pronounced.

Occurrence.—A single corallum here described was found during a Melbourne University geological excursion (3/8/21), at Cave Hill, Lilydale, by Mr. L. E. Stevens, who has presented the larger portion to the National Museum.

Age.—Silurian (Yeringian).

SPONGOPHYLLUM SHEARSII, sp. nov.

(Plate XIV., Figs. 18a, b; Pl. XV. Figs 25, 26.)

Description.—Corallum massive, astraefiform. Corallites polygonal, fairly uniform and mainly hexagonal. Thecal walls thinner than in the preceding species, but apparently less closely united, since the coral weathers into prismatic fragments, unlike *S. stevensi*. Septa about 20 to each corallite, alternately long and short, the larger ones extending nearly to the centre, the shorter being only one-sixth the length. Vesicular dissepiments are seen in horizontal section as straight or oblique, thin or wavy partitions, aggregated near the centre.

14.—Pal. Foss. des Terr. Pal., 1851, p. 425. *Idem*, Mon. Brit. Foss. Corals (Pal. Soc. Mon.), 1853, p. 242, Pl. LVI., Fig. 2, 2a-c.

Dimensions.—A large fragment of a corallum—Holotype—from which sections were cut, measures about 16 cm. in height.

The corallites averages 5 mm. in diameter.

Observations.—The above species is closely related to *Spongophyllum stevensi*, but certain differences exist which make it easily separable.

In *S. shearsbii*, as compared with *S. stevensi*, the septa are less numerous; the primary septa are larger; and the dissepiments are roughly zoned near the centre, as in Etheridge's *S. bipartita*.

S. shearsbii differs from *S. bipartita* (se *postea*), in having both primary and secondary septa; in the presence of a well-defined thecal wall; and in the definite attachment of the distal ends of the primary septa to the corallite wall.

In some respects it agrees with Foerste's *S. spongophylloides*,¹⁵ as in the presence of primary and secondary septa; but the latter are more numerous in *S. shearsbii* and the epithecal wall considerably thicker.

Occurrence.—In the Silurian of Hatton's Corner, Yass, New South Wales. Presented to the National Museum by A. J. Shearsby, F.R.M.S.

SPONGOPHYLLUM BIPARTITA, Etheridge fil. sp.

(?) *Lonsdaleia* (*Spongophyllum*) *bipartita*, R. Etheridge, junr., 1889, Records Geol. Surv. New South Wales, Vol. I., Pt. I., p. 22, Pl. III.

Observations.—In his paper "On the Occurrence of a Coral Intermediate in Structure between the Genera *Lonsdaleia* and *Spongophyllum*, in the Upper (?) Palaeozoic Rocks of New South Wales, the late Mr. Etheridge, junr., described in detail this well-known Australian Silurian Coral.

For a long time it seems to have been a matter of doubt as to the conspecific relationship of Foerste's *S. spongophylloides*¹⁶ with the above form, and whose description was published in the preceding year. Thus Dr. Foerste himself wrote to me in April, 1920, "I should very much like to learn what is the present standing of those species," enumerating several, remarking, "Is *Endophyllum spongophylloides* the same as *Lonsdaleia bipartita*?"

Although Foerste's species, "*Endophyllum*" *spongophylloides*, judging by his figures and descriptions, approaches very closely to Etheridge's *S. bipartita*, there are certain important differences which prevent the absorption of *S. bipartita* into *S. spongophylloides*. Foerste's description was not so detailed as could be wished, probably on account of sparse material, and differences

15.—*Endophyllum spongophylloides*, Foerste. Bull. Lab. Denison Univ., Vol. III., 1888, p. 131, Pl. XIII., Figs. 16. 17.

16.—*Vide supra*.

in both figures showing septation offer reasons against their correlation. In Foerste's paper his species is misspelled "*spongophylloides*" in the text, and "*Spongophylloides*" in the explanation to Plate XIII., but is noted lower on that page.

The following diagnoses taken from Foerste and Etheridge respectively, will show their close but not identical relationship.

	Foerste (<i>S. spongophylloides</i>)	Etheridge (<i>S. bipartita</i>)
Diam. of corallite	9 mm.	10 mm. (mean)
transverse outline	polygonal or hexagonal	polygonal (pentagonal, quadrangular or hexagonal)
"	thin walls	thin epitheca
"	vesicular tissue about the walls.	"vesicular outer zone"
"	inner "zone in which the vesicular tissue is combined with radiating lamellae"	"The septal . . . area of vertical lamellae is of medium size, the septa starting in an irregular and ill-defined manner, from the distal row of vesicular plates"
Septa	shown in Foerste's figure average 12	Septa 18 to 20
"	primary and secondary as seen in Pl. XIII., Fig. 16	"all primary"

In the above synopsis it will be seen that Foerste's enumeration of the septa does not agree with Etheridge's, in the former averaging 12 against 18 to 20 in the latter. This fact, taken in conjunction with the figure where Foerste shows the septa (lamellae) as of two orders, thus opposed to Etheridge's statement that they "are all primary," compels us to regard the two forms as distinct.

Occurrence.—Silurian. Hatton's Corner, Yass, New South Wales. Several examples collected and presented by A. J. Shearsby, F.R.M.S., and by W. S. Dun, F.G.S.

Genus *Columnaria*, Goldfuss.

COLUMNARIA FLEMINGTONENSIS, sp. nov.

(Plate XIV., Figs. 19a, b ; Pl. XV., Fig. 28.)

Description.—Holotype, in a ferruginous mudstone, preserved as a negative cast. Characters described from a wax squeeze. Corallum fairly large, a fragment only preserved, measuring 5.3 cm.×3.3 cm.; consisting of polygonal corallites having an average diameter of 5 mm. Walls of corallites moderately thick, well defined. Septa regular, about 15 primary and the same number of secondary, the primary extending to the centre, but only occa-

sionally meeting to form a twisted false columella. Tabulae concave proximally.

Observations.—The above species is extremely interesting from the fact that it combines the characters of several already known forms. Thus it has the thick epithecal walls seen in *C. halli*, Nicholson¹⁷, but without the clear, non-septate calycinal cup; the long septa of *C. calicina*, Nicholson¹⁸, but more numerous than in that species; the strong corallite walls, as in *C. neminghensis*, Etheridge fil.¹⁹, but with more regular and numerous septa and smaller corallites. From *Loyolophyllum cresswelli*, Chapman sp.²⁰, previously described by the author as a subgenus of *Columnaria*, but which, as suggested by the late Robert Etheridge junr. is generically distinct, it differs in having no outer vesicular zone nor deep concave tabulae; whilst the corallites in the present species are nearly five times the diameter.

Occurrence.—Silurian (Melbournian). In the grey and brown ferruginous sandy mudstone of Moonee Ponds Creek, near Flemington, Victoria.

Coll. Geol. Surv. Victoria.

EXPLANATION TO PLATES.

PLATE XII.

Fig. 1.—*a-f. Lindstroemia yeringae*, sp. nov.: *a*, Holotype, exterior showing striated epitheca; *b* and *c*, examples showing general external characters; *d*, example sliced vertically, showing floor of calice with upward growth of columellar partitions; *e*, Paratype, vertical section, showing septation with dissepiments; *f*, Paratype, exterior, showing growth stages.

Silurian (Yeringian). Yering, Upper Yarra. Geol. Surv. Vict. B 15. Nat. size.

Fig. 2.—*Lindstroemia parva*, sp. nov. Exterior showing coarse epithecal striae. Silurian (Melbournian). Yan Yean, near Whittlesea. Geol. Surv. Vict. Bb 13. Holotype. ×2.

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- 17.—*Columnaria alveolata*, J. Hall (non Goldfuss), 1847, Pal. New York, Vol. I. p. 47, Pl. XII., Figs. 1, 1a-c. *Columnaria* (?) *halli*, Nicholson, 1879, Palaeozoic Tabulate Corals, p. 200, Pl. X., Figs., 3, 3a. *Columnaria halli*, Nich., Lambe, 1901, Contrib. Canadian Palaeont., Vol. IV., Pt. II., p. 100, Pl. VI., Figs. 2, 2a.
- 18.—*Favistella calicina*, Nicholson, 1874, Rep. Brit. Assoc. Trans. of Sections, p. 89; Id., 1875, Palaeont. Ontario, p. 24, Figs. 9a, b. *Columnaria hertzeri*, Röminger, 1876, Geol. Surv. Michigan, Fossil Corals, p. 90.
- 19.—*Columnaria calicina*, Nicholson, 1879, Palaeozoic Tabulate Corals, p. 197, Pl. X., Figs. 2, 2a. Lambe, 1901, Contrib. Canad. Palaeont., Vol. IV., Pt. II., p. 102, Pl. VI., Fig. 4.
- 20.—Rec. Austr. Mus., Vol. XII., 1913, p. 50, Pls. VIII., IX.
- 20.—*Columnaria* (*Loyolophyllum*) *cresswelli*, Chapman, 1914, Rec. Geol. Surv. Vict., Vol. III., Pt. 3, p. 306, Pl. LI., Figs. 15, 16; Pl. LII., Figs. 17, 18.

- Fig. 3.—*L. parva*, sp. nov. An immature form, showing coarsely striated surface. Silurian (Melbournian). Yan Yean, near Whittlesea. Geol. Surv. Vict. Bb 13. Paratype. $\times 2$.
- Fig. 4, *a-e*.—*Lindstroemia ampla*, sp. nov. *a*, Holotype, exterior of a well-developed example; *b*, Paratype, corallum of medium growth; *c*, Paratype, vertical section of corallum, show deep calyx and short, septate columella, the cup filled with crinoidal debris. Silurian (Yeringian). Yering, Upper Yarra. Geol. Surv. Vict. B 15. *a*, *b*, nat. size; *c*, $\times 2$.
- Fig. 5.—*Lindstroemia conspicua*, sp. nov. Cast in mudstone. Silurian (Melbournian). South Yarra. Holotype; coll. F. P. Spry. Circ. nat. size.
- Fig. 6.—*L. conspicua*, sp. nov. Cast of basal portion of corallum in mudstone. Silurian (Melbournian). South Yarra. Paratype; coll. F. P. Spry. Nat. size.
- Fig. 7.—*L. conspicua*, sp. nov. Cast in ferruginous mudstone, showing floor of calyx, with indications of septal polarity. Silurian (Melbournian). Moonee Ponds Creek. Paratype; coll. J. F. Bailey. Circ. nat. size.
- Fig. 8, *a*, *b*.—*L. conspicua*, sp. nov. *a*, Cast of floor of calyx in black mudstone; *b*, lateral view of cast of corallum. Silurian. Wandong, Vict. Paratype; coll. F. W. Rowe. Nat. size.
- Fig. 9.—*Lindstroemia scalaris*, sp. nov. Cast of corallum, showing conspicuous growth stages. Silurian. Glenburnie Road, Whittlesea. Holotype; coll. J. T. Jutson. Nat. size.
- Fig. 10.—*L. scalaris*, sp. nov. Cast of corallum, showing growth stages and coarse epithecal striae. Silurian (Melbournian). Hawthorn Brick Quarry, near Melbourne. Paratype; pres. R. H. Annear. Nat. size.

PLATE XIII.

- Fig. 11.—*Cyathophyllum cresswelli*, sp. nov. Holotype (one-half), vertical section, showing large central dissepimental area, with thin tabulae. Silurian (Yeringian). Cave Hill, Lilydale. Coll. Rev. A. W. Cresswell, M.A. Nat. size.
- Fig. 12.—*C. cresswelli*, sp. nov. Polished horizontal surface section, showing septal zone and calicinal cavity. Silurian (Yeringian). Cave Hill, Lilydale. Paratype. Coll. Rev. A. W. Cresswell, M.A. Nat. size.
- Fig. 13.—*C. cresswelli*, sp. nov. Horizontal section (thin slice), showing dissepiments of septal zone. Silurian (Yeringian). Cave Hill, Lilydale. Slice taken from the preceding specimen. Nat. size.
- Fig. 14.—*C. cresswelli*, sp. nov. Lateral aspect of an immature example. Silurian (Yeringian). Cave Hill, Lilydale. Paratype; pres. by R. H. Annear. Nat. size.

Fig. 15.—*Cyathophyllum subcaespitosum*, sp. nov. Polished surface of corallum, showing fasciculated corallites in horizontal section. Silurian (Yeringian). Cave Hill, Lilydale. Holotype; pres. Rev. A. W. Cresswell, M.A. Nat. size.

Fig. 16, *a*, *b*.—*C. subcaespitosum*, sp. nov. *a*, polished horizontal surface of a small specimen; *b*, same specimen in lateral aspect. Silurian (Yeringian). Cave Hill, Lilydale. Paratype. Coll. Rev. A. W. Cresswell, M.A. Nat. size.

PLATE XIV.

Fig. 17 *a*, *b*.—*Spongophyllum stevensi*, sp. nov. *a*, horizontal section of corallum; *b*, longitudinal section of corallum. Silurian (Yeringian). Cave Hill, Lilydale. Slices (tectotypes), cut from holotype, pres. by L. E. Stevens. \times circ. 2.

Fig. 18 *a*, *b*.—*Spongophyllum shearsbii*, sp. nov.; *a*, polished horizontal section of corallum; *b*, vertical section of corallum. Silurian. Hatton's Corner, Yass, N.S. Wales. Cotypes, pres. A. J. Shearsby, F.R.M.S. Nat. size.

Fig. 19 *a*, *b*.—*Columnaria flemingtonensis*, sp. nov. *a*, Holotype (negative cast); *b*, wax squeeze, giving positive aspect. Silurian (Melbournian). Moonee Ponds Creek, Flemington. Geol. Surv. Coll. Nat. size.

PLATE XV.

Fig. 20.—*Lindstroemia yeringae*, sp. nov. Section across summit of corallum, showing two cycles of septa. Silurian (Yeringian). Yering, Upper Yarra. Tectotype, G. S. V. B15. $\times 3$.

Fig. 21.—*L. yeringae*, sp. nov. Section at about 6 mm. above base of corallum, showing primary septal cycle and central point of coalescence. Silurian (Yeringian). Yering, Upper Yarra. Tectotype. G. S. V. B15. $\times 3$.

Fig. 22.—*Lindstroemia ampla*, sp. nov. The same example as in Fig. 4c. Drawing to show structure of floor of corallum, with coalescence of septa by dissepiments. $\times 2$.

Fig. 23.—*Lindstroemia conspicua*, sp. nov. Wax impression of a cast of the floor of the calyx (see Fig. 8a), showing feeble, zaphrentoid structure. Silurian. Wandong. $\times 2$.

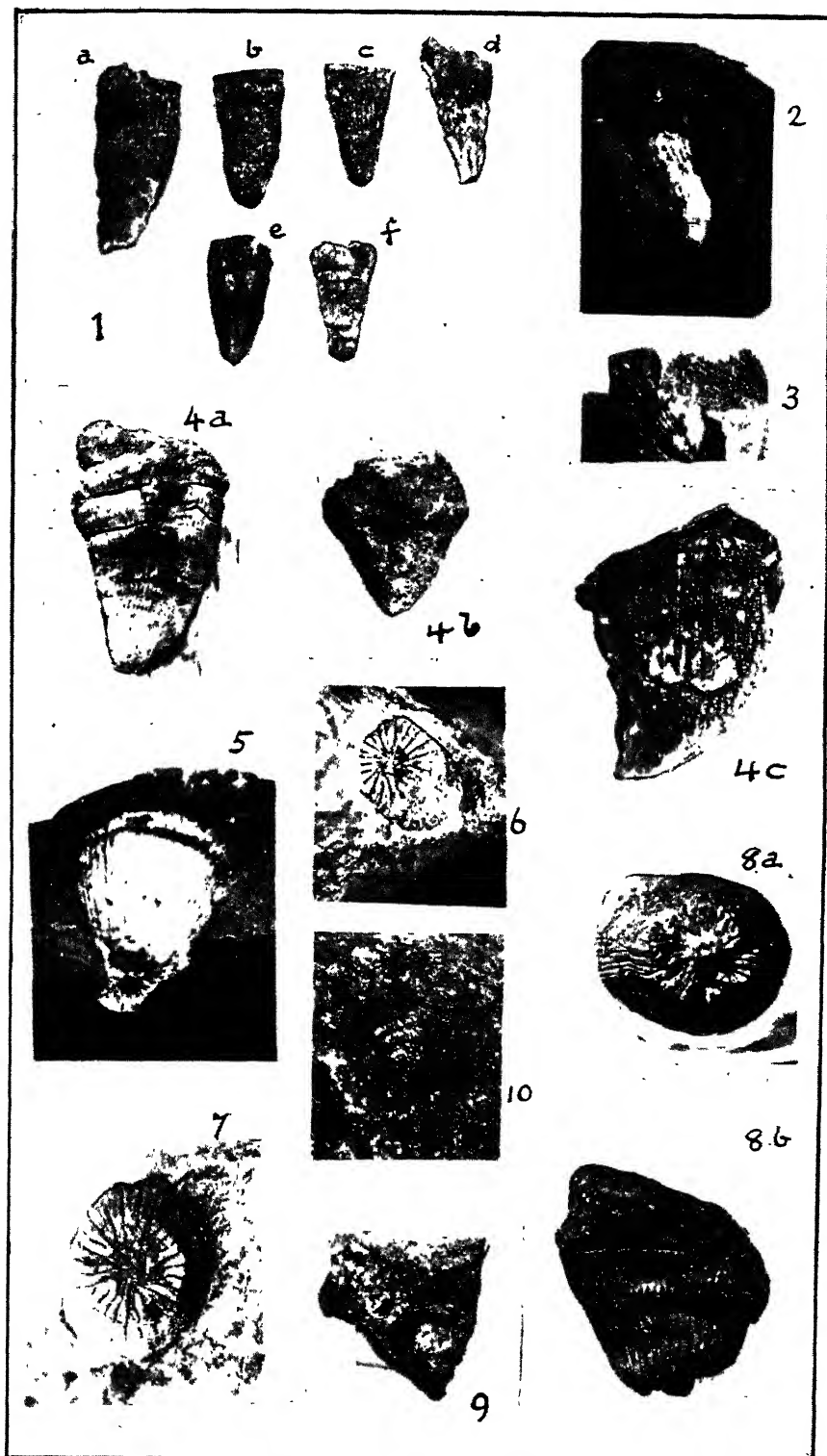
Fig. 24.—*Spongophyllum stevensi*, sp. nov. Corallite enlarged. Transverse section. $\times 2$.

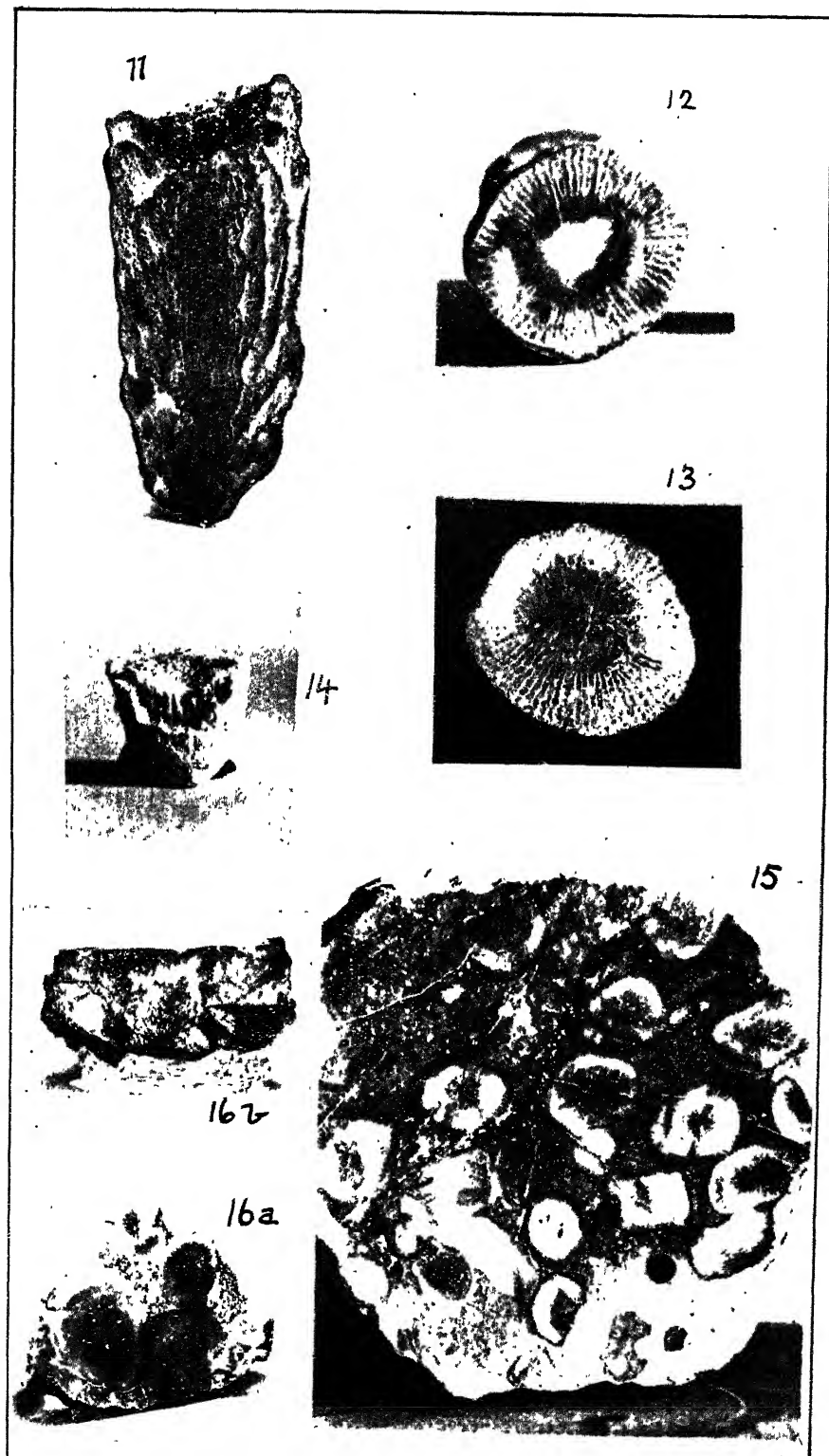
Fig. 25.—*S. shearsbii*, sp. nov. Corallite enlarged. Transverse section. $\times 3$.

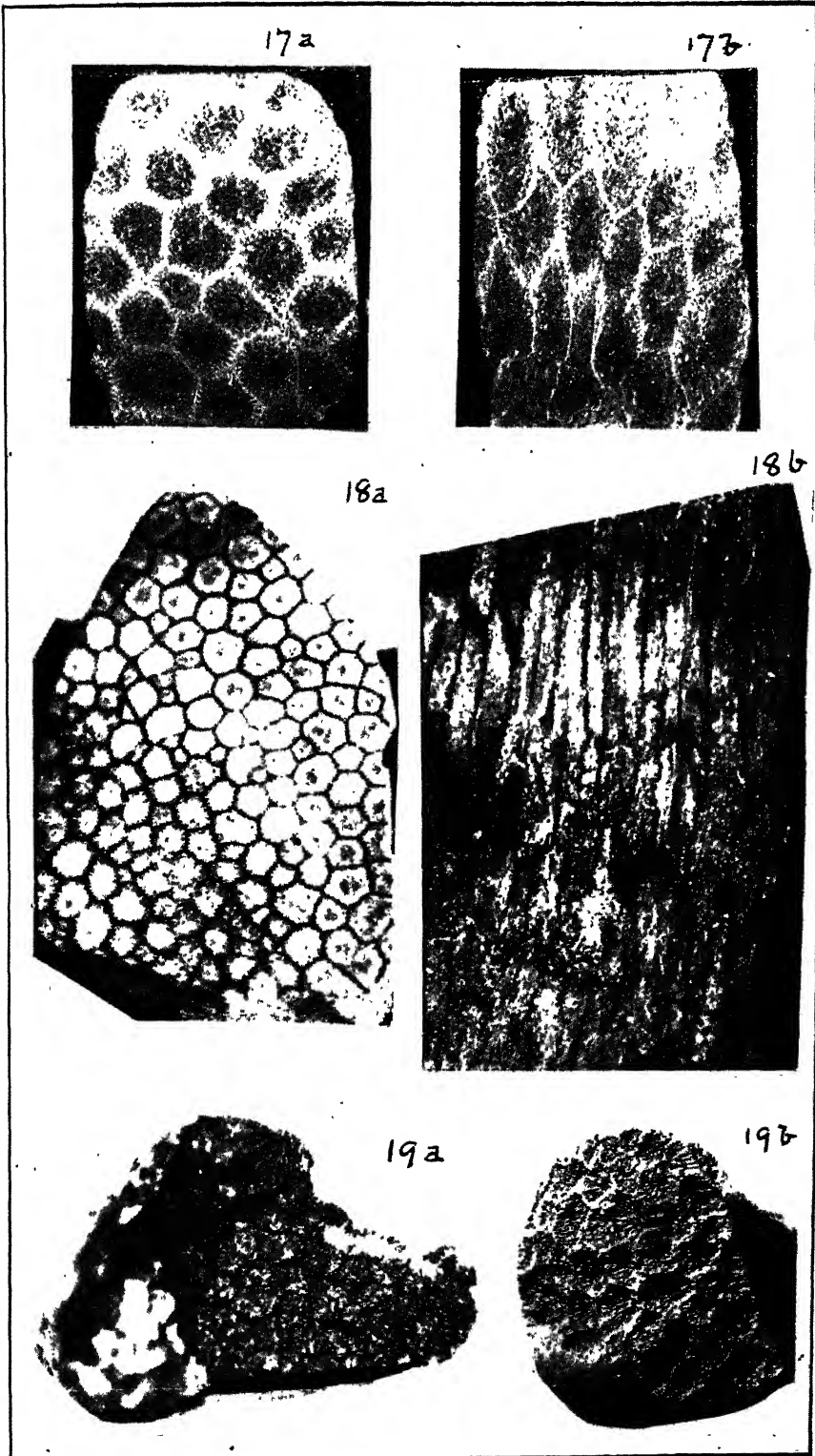
Fig. 26.—*S. shearsbii*, sp. nov. Corallite in vertical section. $\times 2$.

Fig. 27.—*S. stevensi*, sp. nov. Original contour of Holotype. One half diameter of specimen.

Fig. 28.—*Columnaria flemingtonensis*, sp. nov. A calice from a wax impression. $\times 3$.

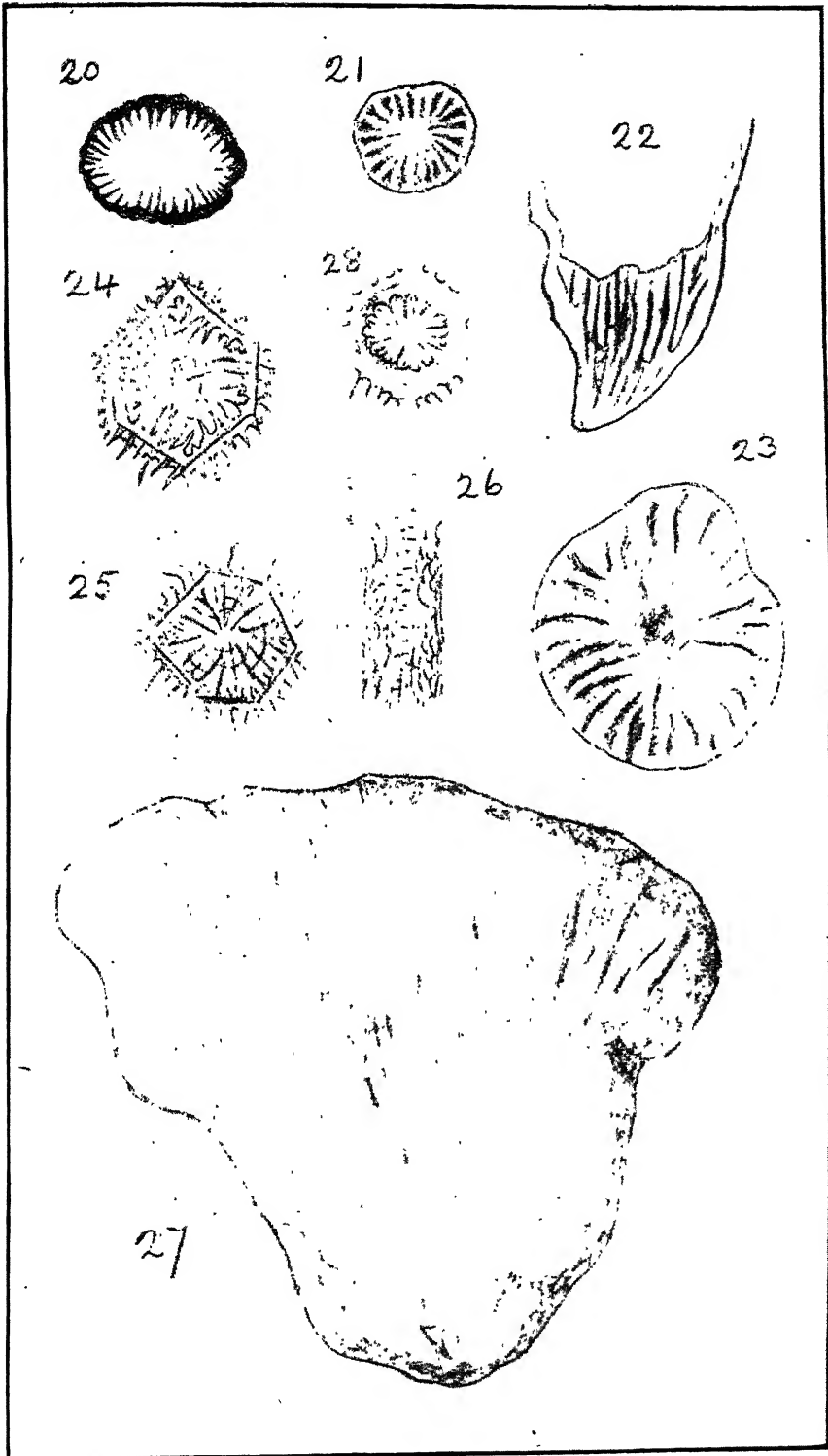






F.C. Photo

Spongophyllum and Columnaria.—Silurian:
Victoria and N.S. Wales.



ART. VIII.—Notes on *Mastotermes darwiniensis* Froggatt
(Isoptera).

By GERALD F. HILL.

(Entomologist to the National Museum of Victoria).

[Read 17th July, 1924.]

Quite apart from the importance of *Mastotermes* as a factor in the economic development of certain parts of tropical Australia, this insect, in some respects the most primitive of all *Isoptera*, is of considerable academic interest on account of its relationship with the Orthopteroid Families *Blattidae* and *Mantidae*. The closeness of the relationship between *Mastotermes* and the *Blattidae* has been demonstrated recently as a result of the morphological studies of Crampton, who records in his latest paper (1923) the presence beneath the 7th sternite of the alate female of the former "a fully formed ovipositor composed of three pairs of well-developed valves—a thing never before found in any winged termite, so far as I am aware!" On a subsequent page of the same paper he states:—"In the *Isoptera*, *Blattids* and *Mantids* . . . the 7th sternite becomes elongated posteriorly to form a sub-genital valve. . . . which partly conceals the ovipositor in *Mantids*, and completely hides the ovipositor in most *Blattids* and such termites as have an ovipositor." I do not know what function this structure has in *Mastotermes*, but in the roach . . . the inner walls of the hypogynum form the lining of an oothecal cavity in which the ootheca is carried about by the mother roach for a period. . . . It is probable that in *Blattids*, *Mantids* and *Isoptera* the hypogynum forms a genital cavity functioning in the process of mating." From the above it appears to me that Crampton must have been on the verge of discovering the remarkable mode of oviposition recorded by me a few weeks later in a paper read at the second Pan-Pacific Congress, wherein it was stated that:—"The nearest allies of *Mastotermes* are found in the Family *Calotermitidae* . . . but there are morphological characters in the former which differentiate them sharply from the *Calotermes*. . . . The highly developed wings and the possession of a true worker caste in *Mastotermes* are among the important distinguishing features . . . but they are of less importance than the remarkable development of the reproductive organs of the female and the mode of oviposition. The external genitalia are unlike those of any other species of termite inasmuch that the comparatively simple structure of the *Calotermes* is represented in *Mastotermes* by a more complex arrangement closely resembling the *Blattidae* in general and some of the northern

species in particular. In all other known species of termites . . . the eggs are extruded separately . . . but in *Mastotermes* they are extruded in masses, each comprising from 16 to 24 eggs . . . cemented together laterally to form two parallel rows. These hitherto unrecorded facts demonstrate a relationship between the *Blattidae* and the *Termitidae* far closer than has been previously suggested."

The foregoing was written in ignorance of Crampton's work, and was not accompanied by detailed descriptions and figures of either the insect or its egg-mass; nor is it my intention now to discuss the former in view of the above writer's published work and his special qualification for a study of the ample material now in his possession, but it seems advisable to give some further details and a figure of the latter, as well as some field observations, in view of the fact that such specimens are likely to remain rare objects in entomological collections.

As a general account of the habits of *Mastotermes*, and its importance as a pest, appeared in a recent publication (Hill, 1921) it is unnecessary to refer to them again here; it may be mentioned, however, that the range of distribution in North Australia is somewhat greater than has been recorded previously, i.e., to the 23rd degree S. lat. on the East Coast, to the 20th degree in Central Australia, and to the 22nd degree on the West Coast.

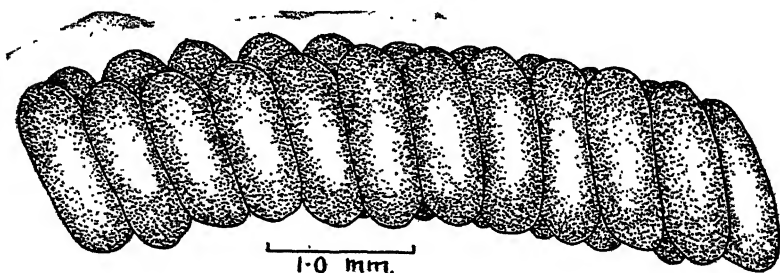


FIGURE I.

Egg-mass of *Mastotermes darwiniensis* Froggatt.

The Egg-mass.—The egg-mass (Text-fig. 1) is tawny in colour, and generally contains 22 or 24 eggs (rarely as few as 16). laid side by side in two parallel rows. The eggs rest at an angle of from 65 to 80 degrees from the perpendicular, and are so placed that when viewed from the side the upper and lower surfaces of the mass are convex and concave respectively. The individual eggs are firmly cemented together by a light brown gelatinous secretion, which is sufficiently copious to completely fill the interstices between the eggs and, in some places, to extend to the exposed outer surfaces. Under a low power (Oc. 4, obj. 2/3) the shell appears to be smooth and glossy. The following are details of the two masses now available for examination:—

	A.	B.
Extreme length of mass	5.13	4.44
„ width „	0.68	0.68
„ depth „	1.11	1.00
Number of eggs in mass	22	24
Eggs, long	1.08 to 1.25	
„ wide	0.39 to 0.40	

The Nest and Its Occupants.—The nest from which these eggs were taken (30 miles S.E. of Darwin, Northern Territory, 21/11/13) was situated at the base of a fence-post ten inches in diameter, which had been cut from a sound growing tree and erected four years earlier on a well-drained gravelly ridge. Within two years *Mastotermes* had so far destroyed the entire line of posts that the wires were removed for use elsewhere, and at the end of the fourth year most of the posts had completely disappeared, only a row of holes and fragments of timber indicating the former line of fencing. The post in which the nest was situated was reduced to a mere shell above ground level, and was practically non-existent below, the wood having been almost entirely removed and replaced by tier upon tier of large cells and galleries enclosed in a casing composed of a mixture of comminuted wood and earth. The colony, excepting a few soldiers and workers, was found below ground level, the upper portion of the post being almost filled with earth and alimentary rejectamenta. Many soldiers and workers were found in passages radiating from the nest at varying depths below the surface, and extending into the surrounding soil. These subterranean passages measured from 6 to 7 mm. in height by 10 to 12 mm. across, and, in the vicinity of the nest, were “floored” with a deposit of rejectamenta up to 2 mm. in depth. Four or five egg-masses were found near the bottom of the nest, but it is probable that many more were overlooked among the nest debris and thousands of struggling termites and ants. Individuals representing all stages of development, from recently hatched larvae to mature workers, soldiers and imagos, were abundant, but no “first-form” or “third-form” kings or queens were found, although both may have been present. In this, as in other cases, very careful examination was almost impossible owing to the attacks of thousands of ants (*Iridomyrmex sanguineus* Forel) upon both the termites and myself.

Masses of eggs similar to those previously described were found subsequently in this locality in January and June. On both occasions “third-form” neoteinic males and females were found, but there was no trace of “first-form” kings and queens, though they may have been present. Recently hatched larvae have been found throughout the year, indicating that egg-laying is not confined to any particular season.

Reproductive Castes.—“First-form” or “true” kings and queens, i.e., reproductive forms derived from de-alated imagos,

have not been found in this species. I attribute this fact firstly to the great difficulty one has experienced in finding the nests, and, having found them, in being able to investigate them carefully, secondly to the probability that both "royalties" are scarcely larger and less active than the de-alated imagos from which they have developed, and, thirdly, to the circumstance that all the nests I have seen were occupied at the time by many hundreds of fully developed alate, or accidentally de-alated, insects, among which the reproductive individuals would be difficult to find.

"Second-form" kings and queens (i.e., neoteinics derived from nymphs of the "second-form") also are unknown. It seems probable that they do not exist in this species.

"Third-form" kings and queens (i.e., neoteinics derived from nymphs of the "third-form" or stage, preceding the first appearance of wing-buds do occur, however, and have been found twice in nests and on several occasions with foraging parties of soldiers and workers. A small colony, comprising about one thousand more or less mature workers and soldiers, accompanied by six male and two female "third-form" neoteinics, was found in a small dead stump near Darwin, N.T. (20/4/14). There was no regular nest and no egg-masses, young larvae, nymphs or "first-form" queen. In the same locality (21/11/13) a well-established but small colony, comprising workers, soldiers, many larvae, several egg-masses, and about five hundred alate males and females, was found to contain also five of these neoteinics, none of which appeared to be ovigerous. Similar individuals were found at Townsville, N.Q.—one in association with a great number of workers and soldiers in the stem of a Pandanus plant, another with workers and soldiers under a heavily infested log, and a third in the base of a much-damaged fence-post.

Description of "Third-form" King and Queen.—Colour uniform dark umber; gross appearance "ergatoid," but easily distinguished from the worker caste by its darker colour, hairy head, thorax and abdomen and narrow head; male with styli and short 7th abdominal sternite; female without styli, and long 7th sternite; antennae 25-jointed; pronotum as in worker; eyes small, 0.285×0.228 mm in diameter, rudimentary, not pigmented; ocelli wanting; head, thorax and legs covered with long, moderately stout reddish hairs, the latter nearly, if not quite, as numerous in soldier and worker, but in both the sterile castes they are very short, fine and pale in colour. Measurements: total length 9.00 to 9.50 mm.; head wide 2.50 (2.67 in worker); pronotum long 1.42, wide 2.56. Ciliates (*Trichonympha*) are present in the hind gut, as in the imago.

Nymphae.—Nymphs of the second and first-form, both of which are to be found together in the nests at the end of August, are alike in having a pronotum resembling that of the imago, styli in both sexes and females with a long 7th sternite, as in the neoteinic queen of the "third form." They are distinguished as follows:—

	Second Form.	First Form.
Total length	12.00 mm.	16.00 mm.
Eyes, diameter	0.513×0.570	0.680×0.85
Head, wide	2.50	3.00
Pronotum, long	1.71	2.05
" wide	3.13	3.87
Mesonotum, to apex of wind-bud,		
long	3.13	6.00
Abdomen, wide	4.00	5.00
Antennae	28-jointed	31-jointed

The above details refer to specimens taken on the same date (21/11/13), and from the same colony. "Second-form" nymphs greatly outnumbered those of the "first-form," indicating that moulting had commenced recently.

It is believed that the number of antennal joints in *Isoptera* increases independently of ecdyses; whether this is so or not I am unable to say, but the rate of increase shown above appears to be remarkable.

Colonizing Flight.—Observations made in Darwin, N.T., and district, during the years 1912-1917, show that the earliest emergence recorded there on 23rd November and the latest on 17th December; whilst the earliest record of fully developed alate imagos in the nest was 21st November. There are no definite records to show the duration of the period intervening between the final moult and the complete hardening of the wings, nor, indeed, of the number of moults through which *Mastotermes* pass in the course of their development. The earliest appearance of wing-buds follows a moult which takes place in January, and the resulting "nymph of the second-form" moults again about the end of August, becoming a "nymph of the first-form," in which stage it remains until the final moult takes place—about the middle of October, it is thought. From thence the young imago develops from the soft-bodied, creamy-white insect with fragile, wrinkled white wings into the dark brown, more or less rigid-winged "flying-ant" so familiar to residents of tropical Australia. In Townsville, where records were kept by the writer for four years, the earliest observed flight occurred on 24th December and the latest on 23rd January. In 1921 there were flights on 24th and 26th December in a limited area affected by local rain storms, but the main flights commenced on 4th January following (the date of the first heavy general rain of the season) and continued at intervals to the 23rd January. In Hughenden, a dry inland district of N. Queensland, flights occurred as late as 4th February in 1922. In Townsville the transition from the third to the second-form nymph has been observed as late as 1st July. The emergence of the flight is determined by climatic conditions; hence their earlier and more regular appearance in the Darwin district, where the rainy season commences earlier and the fall is more regular than in Townsville.

It might be mentioned here that the alate imago, like the soldiers and workers, have no perceptible odour, such as exists in *Rhinotermes*, some *Eutermes*, and, to a marked degree, in some *Blattidae*.

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ART. IX.—*A Revision of the Genus Pultenaea, Part IV.*

By H. B. WILLIAMSON, F.L.S.

(With Plate XVI.)

[Read 17th July, 1924.]

PULTENAEA TRICHOPHYLLA, sp. nov.

Frutex parvus circiter 3 cm. altus, foliis 8-10 mm. longis, lineari-lanceolatis tenuibus actuis concavis supra glabris infra molle patenti-villosis trinerviis quasi verticillatis tenues ramulos alioqui exfoliatis terminantibus, petiolis 2-3 mm. longis, stipulis acutis recurvatis 1-2 mm. longis, floribus minimis 2-3 fere celatis inter foliis terminalibus, calyce 2-3 mm. longo, lobis aequilongis acuminatis, bracteolis 1 mm. longis angustatis acutis sub calyce insertis, ovario minute villosa.

A small shrub about 3 cm. high, with leaves 8-10 mm. long, narrow-lanceolate, thin, acute, concave, glabrous above, below invested with long soft hairs, three-nerved, mostly in bundles at the ends of slender, otherwise leafless branchlets about 1 cm. long. Petioles 2-3 mm. long. Stipules pointed, recurved, 1-2 mm. long. Flowers very small, 2-3, almost concealed by the terminal leaf bundles. Calyx 2-3 mm. long, with pointed, equal lobes. Bracteoles narrow-pointed, 1 mm. long, fixed below the calyx. Ovary beset with minute hairs.

Port Lincoln, Sth. Aus. J. E. Browne.

The peculiar arrangement of the leaves, in false whorls at the ends of slender branchlets, which are bare for about 1 cm., and arise from the axils of leaves on the larger branches, and the very small calyx and narrow-pointed bracteoles distinguish it from its allies, *P. trinervis*, J. M. Black, *P. villifera*, Sieber.

In the National Herbarium, Melbourne, among specimens of *P. involucrata*, which species it resembles in general appearance, but from which it differs in not having flowers singly terminal, and in its bracteoles narrow pointed.

PULTENAEA PUBESCENS, sp. nov.

Frutex erectus parvus, ramulis pubescentibus saepe ferrugineis, foliis 4-5 mm. longis angustis recurvatis apicem versus latioribus margine multum involutis supra vix apertis infra minutissime scabris petiolis 1 mm. longis, stipulis longis et recurvatis latioribus confertisque ad apicem ramulorum floribus prope apicem ramulorum pedicellis 1 mm. longis, bracteis nullis, bracteolis angustatis infra calycem affixis, calyce, 4-5 mm. longo lobis acuminatis minute pubescentibus ovario villosa, stylo subulato.

A small, erect shrub, with branchlets much beset with hairlets, and often rusty coloured. Leaves 4-5 mm. long, narrow, recurved, broader at the summit, almost closed above, scabrous below with minute hairs, on petioles of 1 mm. Stipules long and recurved, broader and much crowded at the summits of the branches. Flowers axillary near the ends of branches, on pedicels 1 mm. long. Bracts none. Bracteoles fixed below the base of the calyx, narrow-linear, often leaf-like with reddish, membranous stipules. Calyx 4-5 mm. long, with acuminate lobes about as long as the tube, minutely pubescent. Ovary villous, style subulate.

South Australia: Mt. Gambier, Lake Bonney, E. Wehl; Victoria: Portland, Allitt; Grampians, Wilhelmi.

It is near *P. recurvifolia* H.B.W., but differs in its rusty red appearance, its leafy stipules and larger calyx. From *P. Readeriana*, H.B.W., it differs in the shape of the calyx, the stipulate bracteoles, axillary flowers and recurved leaves. It has been included under *P. villosa*, Willd., but that species has the ovary glabrous except for a tuft of long, white hairs at the top, and has a calyx with upper lobes much falcate as well as having axillary flowers.

PULTENAEA STYPHELIODES, A. Cunn.

G. Don, in Gen. Syst. ii., 124, 1832.

As it appears improbable that the type has been preserved, an attempt is now made to determine the position of the forms about which so much doubt has existed.

The specimens which have been passing for *P. styphelioides* may be separated thus:—

A.

Foliage resembling that of *Sprengelia incarnata*, Smith; leaves alternate, ovate-lanceolate, rigid, reflexed, ending in a pungent mucrone, rather villous beneath when young, but only at the edges in the adult state, concave, often appressed, and thus appearing to clasp the stem, showing distinct secondary venules below. Stipules conspicuous, reddish, subulate, broader and united on upper branches. Flowers almost sessile, axillary, and crowded near the ends of branches.

Bracteoles inserted on the calyx away from the base, lanceolate, leafy, and provided with membranous stipules. Calyx villous, 5-7 mm. long, lobes subulate, and longer than the tube, upper lobes, large and falcate. Ovary glabrous except for a tuft of long white hairs at the summit.

Ilford and Queanbeyan, H. Deane; Tumut, Cooma, Boorman, Bauerlen; Taloooby, R. T. Baker; Cox's River, Maiden and Cambage; Barren Jack, Cheel; Narrabri Dist., G. Burrows; Booroomba, Cambage; Victoria: Hume River, Jephcott; Mitta, Clinton; Fatters Range and Mt. Pleasant. The last-named is a villous form for which Mueller's MS. name was *P. epacridea*,

Frag., F.v.M., IV., 1863. To the same form are referred specimens from Monaro, N.S.W., Bauerlen; Edwards River, Sullivan.

B.

Leaves mostly in threes, lanceolate, concave, villous below, without showing secondary venules, straight, ending in a straight, fine point, spreading, short stalked. Flowers axillary on pedicels 2-4 mm. long, not crowded. Bracteoles at the base of the calyx without stipules.

New South Wales: Hill End, Dr. Lanterer; Trunkey and Orange, Boorman; Mudgee, N. Taylor; Orange, Cambage; West of Blue Mountains, Miss King; Sofala, Cambage, (2748); Specimens from Kew Gardens, collected by Cunningham, "Murray River."

These forms, to include which Bentham extended Don's description, certainly represent two species. With regard to the Kew specimen, kindly lent for inspection, the Asst. Director of that Institution says: "G. Don, in his Gen. Syst. in taking up Cunningham's MS. name (wrongly printed '*Staphyleiodes*'), does not give a more definite locality than 'New Holland,' and may have drawn up his description from a plant raised from seed sent by Cunningham, of which specimens were not preserved. The type is not in the British Museum."

Don's description reads: "Flowers sessile, solitary, axillary. Leaves ovate, acute, stiff, ending in a pungent mucrone, reflexed, rather villous beneath when young, but only at the edges in the adult state. Habit of *Sprengelia incarnata*, *Staphelia*-like."

There can be little doubt that the "A" specimens conform more to Don's description than those of "B." All the "A" specimens have reflexed alternate leaves, while those of "B" are straight and in threes. Flowers are not nearly sessile in "B" but on pedicels sometimes 4 or even 5 mm. long. It is not probable that such an important character as leaves in threes would have been omitted from Don's description if it were present in the plant; and, again, his reference to *Sprengelia* is easily understood when one looks at the glabrous forms of "A," for although the leaves are not in a true sense clasping, they give that impression when they are appressed, as they often are—e.g., the Cooma, Hume River and Talooby specimens. The name *staphelioides* must, therefore, be retained for all forms of "A," with the amended description as given above. Its position in Sect. *Coelophyllum* is with *P. juniperina* Labill, and *P. costata* H.B.W.

With regard to specimens "B," they stand apart in respect of several important characters, and come under a proposed new species name, "*subternata*."

PULTENAEA STYPHELOIDES, A. Cunn, var. MUTICA, F.v.M.

Under this name Mueller placed specimens from Mt. Pleasant, N.E. Victoria, which differ from the normal in having leaves not

pungent, and sometimes nearly as broad as long. Also at Chiltern, Williamson.

PULTENAEA SUBTERNATA, sp. nov.

P. styphelioides, A. Cunn., partim.

Frutex parvus, ramulis villosis, foliis 6-9 mm. longis plerumque ternatis ovato-lanceolatis concavis rectis patentibus mucronatis nervis latoribus obscuris supra glabris infra villosis petiolis 1 mm. longis, stipulis parvis subulatis, floribus axillaribus pedicellis 2-4 mm. longis, calyce villosos 5 mm. longo lobis subulatis inferioribus tubo longioribus superioribus falcatis, latoribus, bracteolis linearibus subulatis villosis ad basin calyce affixis, ovario glabra, legumine non viso.

Small shrub with villous branches. Leaves from 6 to 9 mm. long, mostly ternate, ovate-lanceolate, straight, concave, spreading, ending in a sharp, straight point glabrous above, villous below, lateral venules obscure. Petioles 1 mm. long. Stipules small, subulate. Flowers axillary, on pedicels 2-4 mm. long. Calyx villous, 5 mm. long, with subulate lobes; lower lobes longer than the tube, upper ones broader and falcate. Bracteoles linear, subulate, exstipulate, villous, fixed at the base of the calyx. Ovary glabrous, except for a tuft of white hairs at the top. Pod not seen.

New South Wales only. Localities as above.

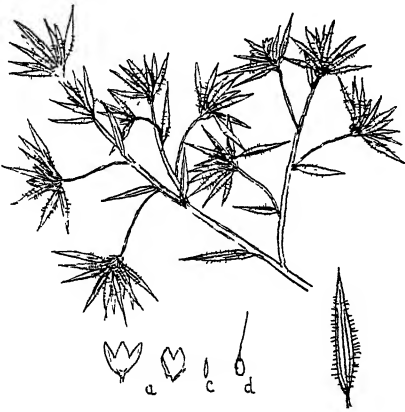
This species can be included under Section *Euchilus*, on account of its ternate leaves, and as it has not the calyx peculiar to that section, it stands as a connecting link between *Euchilus* and *Coelophyllum*.

It is most nearly related to *P. spinosa* (DC.), H.B.W., from which it differs in not being glabrous, obscure secondary venules, shorter pedicels, and different shaped calyx.

PULTENAEA PROCUMBENS, A. Cunn.

In Field, N.S.W., 347, 1838. = *P. setigera*, A. Cunn., Bth., in Ann. Wien. Mus. ii. 82, 1838. = *P. styphelioides*, A. Cunn.

This species seems to have been founded mainly on its procumbent habit. In Maiden and Betcher's "Census of N.S.W. Plants," p. 103, it is stated: "We have erect specimens (*P. procumbens*) in the Herbarium, about 2½ ft. high, collected by Mr. F. Blakey at Bowan Park, near Orange, in November, 1907, which have a very different aspect from the typical *procumbens*, but they differ in no essential characters, and can hardly be separated as a named variety." The Bowan Park specimens are evidently the true *P. styphelioides*. Specimens labelled "*procumbens*" from Munderoorra, Mueller; Cooma, Boorman; and Cox's River, Maiden and Betcher, all agree with the description of *P. styphelioides* as



P. trichophylla, sp. n.



P. pubescens, sp. n.



P. trinervis. J. M. Black.



P. styphelioides, A. Cunn



P. subternata sp. n

amended above, except that in the Mundoora specimens the leaves and flowers are rather smaller.

Don's description of *P. procumbens*, in Field, N.S.W., 147, reads: "Branches prostrate, stipulaceous, racemes leafy, leaves ovate-lanceolate, acute, rather concave above, ending in a refracted mucrone, but villous beneath as well as the calyces, allied to villosa, reclining shrub." The limitations of *P. styphelioides* can be taken to include all forms hitherto known as *P. procumbens* or *P. setigera*.

PULTENAEA TRINERVIS, J. M. Black.

Trans. Roy. Soc. S.A., xlvii., 1923.

A small shrub, with the habit of *P. involucrata*, with rigid, ovate-lanceolate leaves 8-10 mm. long, above glabrous, below villous, and three-nerved, ending in an almost pungent mucrone, on petioles about 2 mm. long. Flowers in axils, calyx 4 mm. long, lobes acuminate, pubescent. Stipules involute, bracts none. Bracteoles ovate-oblong, brownish, concave, inserted under the calyx. Ovary villous.

This is the plant which Bentham mentions on p. 137, Fl. Aust. as "var. *australis*" of *P. villifera*, Sieb.

South Australia: Port Lincoln, R. Brown; F. Mueller; Encounter Bay, Wilhelmi; Mt. Lofty.

PULTENAEA VILLIFERA, Sieb., var. GLABRESCENS, J. M. Black.

Trans. Roy. Soc. S.A., xlvii., 1923.

Differs from the normal in—Leaves broader, almost flat, distinctly pungent, with long hairs only at the margin, not conspicuously three-veined. Calyx lobes scarcely as long as the tube. Bracteoles narrower and more pointed.

Western River, Kangaroo I., H. Griffith.

PULTENAEA DALTONII, H.B.W.

Proc. Roy. Soc. Victoria. Pr. I., 1922.

Brisbane Ranges, Dr. C. S. Sutton, October, 1924, previously known only from Nhill, Vic.

EXPLANATION OF PLATE.

Leafy branches, nat. size.

(a) Calyx lobes $\times 2$.

(c) Bracteoles $\times 2$.

(d) Ovary and style $\times 2$.

END OF VOLUME XXXVII., PART I.

[PUBLISHED 28TH MAY, 1925.]

ART. X.—*Sunspots and Australian Rainfall.**

By E. T. QUAYLE, B.A.

[Read 17th July, 1924.]

In order to guard against any false assumptions with regard to the character of the rainfall response to solar activity of our variously-placed rainfall stations, it was thought advisable to begin this rainfall investigation by a kind of general survey, in which each station is treated individually.

The method followed was to divide the sunspot cycle into three parts, equal in case of a twelve-year period. The first and second are all of four years each; the third usually of three years. The first begins with the year showing by its sunspot number that the rate of rise characteristic of the rising phase of sunspot activity has been attained; the second is the period of the decline; the third is the three or four years covered by the minimum sunspottedness. The rising phase in every case includes the year of maximum sunspottedness.

Now we have many stations scattered over the continent with records covering several sunspot cycles, and we may separate their records in accordance with the treatment of the sunspot cycles. Thus a station with, say, seventy years' record, will cover six complete sunspot cycles, giving twenty-four years under conditions of rising solar activity, twenty-four years for the declining phase, and, say, twenty-two for the minimum periods. Such lengths of record are usually considered sufficient to give a good indication of the average rainfall at most Australian stations.

In the following table practically all the stations with reasonably long records are used. The stations are grouped as conveniently as possible with regard to climatic districts, and their individual average rainfalls for the three phases of the sunspot cycle are given. In addition to these are given the probabilities that the rains during the given phase will be above or below normal. These are simply the result of a count of the plus and minus rainfall departures from the mean for all years. It was not considered in general advisable to take out district means, as even in any one district it could not be said that all stations were under the same climatic control. For example, in Northern Victoria, stations such as Stuart Mill and Swan Hill would not maintain the same rainfall relation from year to year, the former—a hill station—getting much of its rain with the north-westerly and westerly winds of southern disturbances, the latter being almost entirely dependent for its rains upon disturbances of tropical origin. Similar considerations make it obvious that coastal and inland

*Editor's Note.—Publication of this paper has unavoidably been postponed from Part I. of this volume.

stations might be expected to respond differently to solar influences, and, therefore, should not be grouped together.

In general, the rainfalls used are the annual totals, but a partial exception has been made of the south-eastern wheat areas, where the winter rainfall is of paramount importance. The stations for which only the rainfalls of the winter half of the year, May to October inclusive, are shown, are Deniliquin, Wentworth, Adelaide, and a group of ten Northern Victorian stations—Swan Hill, Echuca, Yarrawonga, Warracknabeal, Charlton, Bendigo, Shepparton, Dookie, Horsham, and St. Arnaud. For the last, records are available as far back as 1857, though, in the earlier years, not for the whole ten. The numbers of years' record are also given, so that some idea can be formed of the value of the contribution from each stations;—

TABLE I.

Station	No. of years of record	Rainfall average during phases of Sunspot Cycle			Probabilities of rain above normal.		
		Rising 4 years	Decl'ing 4 years	Min'mum 3 or 4 y'rs	Rising	Decl.	Min
SOUTH-EASTERN WHEAT AREAS (Winter Rains).							
Northern Victoria	- - 66	1223	1138	963	50	50	17
(Mean of 10 stations.)							
Deniliquin	- - - - 64	1034	918	832	50	38	28
Wentworth	- - - - 55	806	658	582	50	40	33
Adelaide	- - - - 84	1506	1504	1322	50	48	28
CAPE YORK PENINSULA AND GULF OF CARPENTARIA.							
Mein	- - - - 35	4865	4761	4629	50	58	45
Georgetown	- - - - 51	3183	3616	3022	38	60	40
Normantown	- - - - 51	3936	4065	3755	44	50	47
Burketown	- - - - 36	3038	2946	2418	33	54	36
EASTERN INTERIOR OF CONTINENT.							
Cloncurry (Q)	- - - 39	2309	1965	1594	58	50	9
Springsure (Q)	- - - 56	2859	2657	2336	55	50	25
Aramac (Q)	- - - 43	2001	1857	1763	50	50	45
Barcaldine (Q)	- - - 36	2346	2057	1841	67	31	36
Blackall (Q)	- - - 43	2481	2108	1928	63	38	9
Charleville (Q)	- - - 45	2256	1984	1791	53	39	25
Tambo (Q)	- - - 42	2327	2360	1948	57	40	31
Bourke (N.S.W.)	- - - 50	1490	1433	1210	50	53	27
Brewarrina (N.S.W.)	- - - 48	1550	1707	1233	50	60	25
Dubbo (N.S.W.)	- - - 50	2124	2316	2135	47	56	40
Wilcannia (N.S.W.)	- - - 44	1051	962	991	50	44	42
PACIFIC COAST.							
Cardwell	- - - - 52	8768	8226	8636	53	45	67
Cooktown	- - - - 49	7186	7407	6836	31	50	33
Townsville	- - - - 52	5063	4876	4418	53	50	40
Mackay	- - - - 52	7326	6526	6822	53	40	33
Rockhampton	- - - - 53	3980	3892	3972	44	40	53
Maryborough	- - - - 53	4758	4761	4359	39	55	33
Gympie	- - - - 53	4559	4617	4383	44	50	40
Brisbane	- - - - 71	4506	4727	4391	33	50	43
Sydney	- - - - 83	4749	4616	5133	36	27	50

Station	No. of years of record	Rainfall average during phases of Sunspot Cycle			Probabilities of rain above normal.		
		Rising 4 years	Decl'ing 4 years	Min'um 3 or 4 y'rs	Rising	Decl.	Min.
PACIFIC SLOPE AND TABLELANDS.							
Charters Towers - - -	41	2821	2210	2410	57	50	47
Clermont - - - - -	47	2943	2686	2679	50	56	31
Taroom - - - - -	47	2896	2613	2555	54	42	47
Dalby - - - - -	53	2695	2509	2540	67	45	27
Banana - - - - -	52	2898	2752	2524	65	55	40
Goondiwindi - - -	44	2615	2542	2429	56	50	42
Warwick - - - - -	58	2882	2709	2805	55	30	44
Bathurst (N.S.W.) - -	64	2479	2424	2213	48	46	41
SOUTH AUSTRALIA—UPPER NORTH.							
Outalpa - - - - -	55	932	988	857	50	45	40
Port Augusta - - - -	63	995	1043	834	52	42	33
SOUTH AUSTRALIA—WESTERN INTERIOR.							
Yardea - - - - -	46	1018	1098	1092	38	44	50
TERRITORY AND CENTRAL AUSTRALIA.							
Katherine - - - - -	50	3621	4135	3858	38	58	47
Daly Waters - - - -	50	2305	3071	2511	19	63	38
Powell's Ck. - - - -	49	1668	2102	1744	25	67	33
Tennant's Ck. - - - -	49	1463	1587	1405	38	67	53
Alice Springs - - - -	49	973	1323	1043	31	56	20
Charlotte Waters - -	49	455	631	602	38	50	47
William Ck. - - - - -	49	485	598	556	44	56	47
N. AND W. COASTAL.							
Darwin - - - - -	53	6296	6488	5689	56	45	20
Wyndham - - - - -	37	2741	2643	2605	58	43	55
Derby - - - - -	37	2685	2800	2471	42	43	55
Cossack - - - - -	41	1160	1114	1188	37	44	27
Onslow - - - - -	37	904	898	881	50	36	36
Carnarvon - - - - -	40	1023	968	817	69	50	27
Geraldton - - - - -	45	2018	1789	1815	50	38	36
Perth - - - - -	47	3489	3412	3249	53	38	47
Bunbury - - - - -	46	3580	3766	3569	44	50	43
WEST AUSTRALIA (Slightly Inland).							
Mt. Florence - - - -	36	1628	1497	1395	58	54	18
Northampton - - - -	41	2138	2010	1944	64	50	36
Walebing - - - - -	39	2242	1916	1772	75	38	36
York - - - - -	46	1943	1736	1563	63	44	36
SOUTHERN.							
Albany - - - - -	46	3778	3712	3519	63	38	43
Eyre - - - - -	38	1145	1121	1184	42	47	55
Eucla - - - - -	47	1000	969	1007	50	44	60
L. Hamilton - - - - -	46	1717	1658	1698	63	38	50
Pt. Lincoln - - - - -	57	2080	1942	1860	70	50	41
Melbourne - - - - -	80	2676	2694	2463	50	48	35
Hobart - - - - -	82	2445	2397	2247	46	48	28

Inspection of the table shows that it is in the inland portion of the eastern half of the continent, and especially in the south-east, that the rainfall shows the most direct response to solar activity. Taking, for example, the sixty-six years' record for the ten Northern Victorian stations, we find that for the six four-year periods of rising sunspot activity the mean winter rainfall for the group is 12.2 inches; for the six four-year periods of declining sunspot activity, 11.4 inches; and for the eighteen years of minimum sunspot activity, 9.6 inches. These are striking results. That they are not influenced unduly by the occurrence of three of our worst drought years during minimum sunspot periods, may be seen by counting for these the number of years with rainfalls above the general average. These were only three out of a total of eighteen. Hence, while the probability of a good year occurring is fifty per cent. for the rising and early declining phases, it is only seventeen per cent. for the minimum phase of sun-spottedness. Similar results are given by the individual stations, Deniliquin and Wentworth. With Adelaide, the only thing definite is the dryness of the minimum period.

A good example of the usefulness of the table of probabilities of rains above normal is afforded by Cossack, where the highest average rainfall was that for the minimum phase of sunspot activity, and yet the actual probability of a good season is least during these periods. The anomaly is due to an excessive rainfall, over forty inches, during one of the minimum sunspot years. Alice Springs provides a somewhat similar case. Such anomalies are, however, comparatively rare.

It is fairly evident from this table (1) that the rainfall of the whole of the continent is affected in some way by the solar activity; (2) that it is not affected everywhere in the same way. This is, however, rendered clear by mapping the percentage rainfall departures from normal for all stations during the three chief phases of solar activity. This involves three maps, which were constructed as follow;—

Map I. deals with the sunspot minimum periods, and shows the rainfall in percentage departures from the general mean or normal.

Map II. shows, in the same way, the departures from normal for the rising phase of sunspot activity.

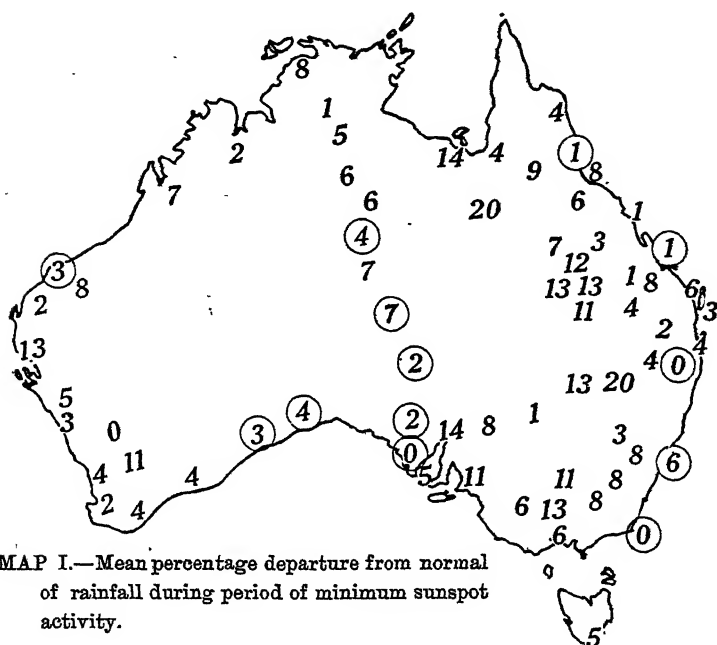
Map III. shows the departures from normal during the declining phase of sunspot activity.

The map results differ widely from one another, and may be described as follows;—

Map I.—The rainfall during the minimum periods of sunspot activity is depressed over the whole eastern interior of the continent by amounts generally ranging between ten and twenty per cent., and to only a slightly less extent over the western interior and Northern Territory. Over east coast

areas and those central areas between the Bight, and, say, Barrow's Creek, it is practically unaffected.

Map II. (rising phase) shows a very great rainfall rebound over the eastern interior and West Australia, of from ten to over thirty per cent., thus carrying it well above normal for the rising period of sunspot activity, but little change on the east coast except that there was an eight per cent. fall at Sydney. There was a further decline over Central Australia and the Territory.



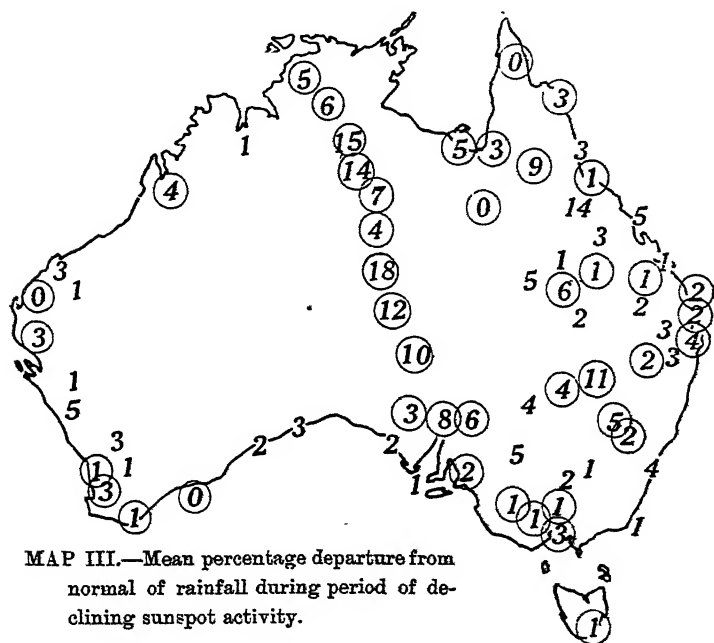
MAP I.—Mean percentage departure from normal of rainfall during period of minimum sunspot activity.

Map III. (declining phase) shows over the eastern interior and in Western Australia a marked decline, bringing the rainfall back to about normal, but a great rise in the rainfall over the Territory and right across the continent to the head of Spencer Gulf, making this distinctly the wettest period. This is probably a feature of great significance.

In the light of our knowledge of Australian meteorology, some tentative explanation of these effects may be offered.

Map I.—It seems probable that the failure of the rain over the eastern interior of the continent during the sunspot minima is due to diminished energy or frequency of the air flows from the tropics, coming by way of New Guinea, Cape York Peninsula, and the Gulf of Carpentaria. The similar rain failure over the western portion of West Australia also

Map III.—For this, the declining phase, the rainfall becomes practically normal over the eastern interior and Western Australia, but makes a most remarkable rise over the Territory, and thence as far south as Spencer Gulf. For the latter, explanation is difficult. It would seem, however, to be a delayed effect, and may be partly due to the necessity for waiting until water accumulations have become fairly common, as well as some recovery in the growth of vegetation. At all events, this would, to some extent, meet the case of the lessened decline



in rainfall during the minimum sunspot period over this area, as compared with that over the rest of the interior. It is probable, however, that the chief cause must be sought in the modifications of the general atmospheric circulation resulting from the variation in solar activity. For example, if, during the rising phase, the eastern and western interiors of the continent are the loci of two separate southward outflows from the equatorial belt, then the area between them, Central Australia and the Territory, may be in the path of return currents, and its dryness explained. The further fall in the Sydney rainfall suggests an increasing west-east drift of the air over the Southern Seas and southern portions of the continent.

Remarks on the Graphs.

Below (Fig. 1) are given graphical representations of the last seven cycles of sunspot frequency and of the rainfalls of various typical inland stations with long rainfall records. The rainfall in each case has been smoothed, the value plotted for any year being the mean for the three years centred about that year. This has the effect of eliminating irregularities due to a suspected three-year period. Of these, Bendigo, which, with the aid of Heathcote during the very early years, goes back as far as 1857, is typical of Northern Victoria. This shows, probably, the closest agreement with the sunspot curve. The annual and the winter (May-October) rains are shown separately. For the latter, I have computed the correlation coefficient, first for the rainfall curve smoothed, next for the curve unsmoothed. The smoothed curve gives the very high correlation coefficient of $+0.63$ (nearly), with a probable error of only ± 0.050 . This is a high coefficient, and, as the probable error is small, less than one-twelfth of the correlation coefficient, it can scarcely be doubted that the variation in solar activity is a dominant factor in the winter rainfall of Bendigo. For the unsmoothed curve, or the actual rainfalls, the correlation coefficient is $+0.46$. The fact of there being such a difference may be taken as pointing to the existence of a three-year period in connection with the rainfall.

Testing Cloncurry and Springsure rainfalls in the same way, we get correlation coefficients of $+0.34$ and $+0.35$ respectively, with probable errors of ± 0.099 and ± 0.079 . These, though reasonably good, are not such indications of solar influence as the Bendigo rainfalls, for which the shorter records and greater rainfall variability are probably partly to blame.

Very interesting results are obtained from the central areas, extending from the Bight to the Upper Territory. As the maps show, the maximum rainfalls here do not occur with, but some years after, the maximum sunspottedness, and a similar lag is shown with minimum rainfalls and sunspottedness.

As three years appeared to be about the amount, I correlated the rainfalls of Daly Waters with the sunspot totals of three years previously. The correlation coefficient proved to be $+0.61$ with probable error ± 0.062 . This is nearly as striking a result as that for Bendigo. The record is a long one—fifty-one years. Assuming the lag to be four years gave better results still, a correlation coefficient of $+0.64 \pm 0.057$.

Alice Springs rainfalls, treated in the same way, gave a lower correlation coefficient, $+0.36$, probable error, ± 0.088 . The lag is not quite so apparent here, and there is some confusion of the factors governing rainfall. Adelaide has the longest record of all, eighty-five years. It is almost in the same belt

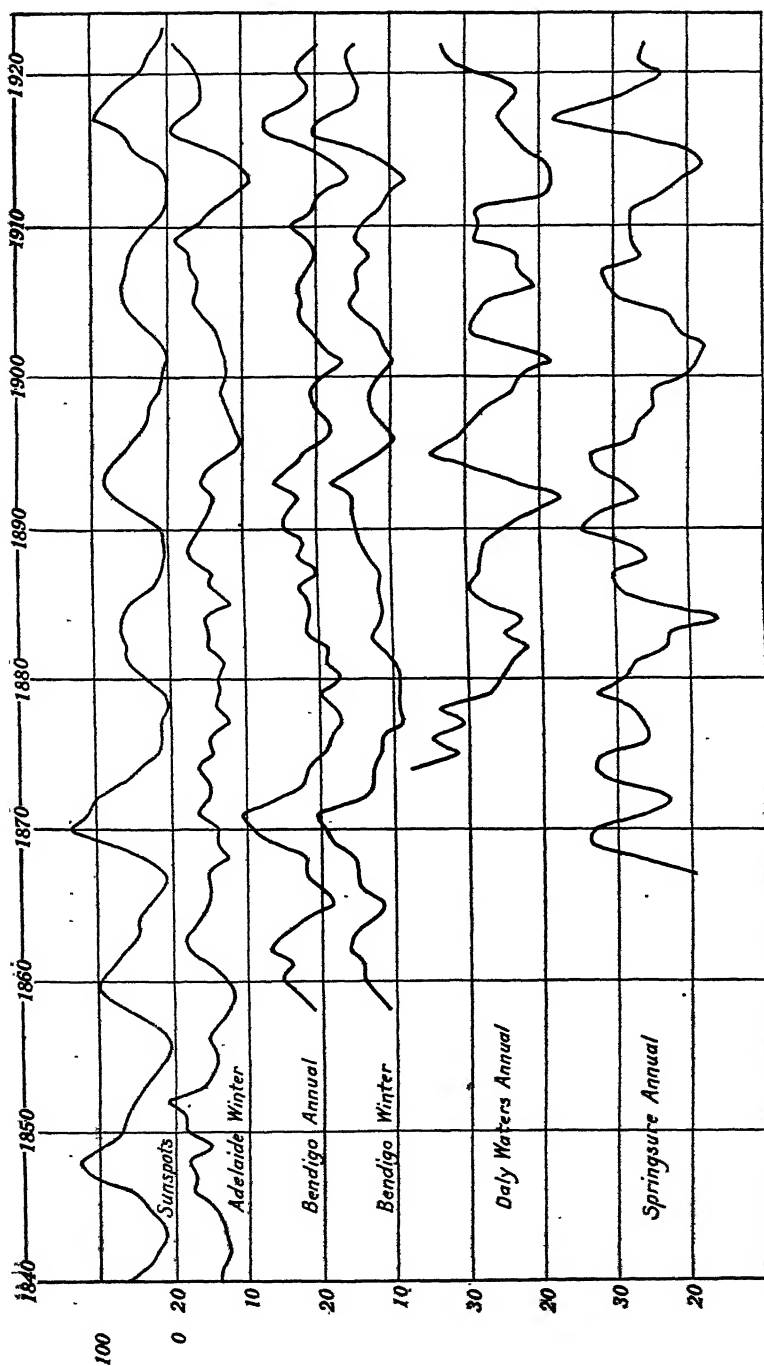


Fig. 1.—Correlation between Rainfall and Sunspots: First Curve Wølfer Smoothed Sunspot Numbers; Remainder, Three-Yearly smoothed Values of Annual or Winter Rain. One Vertical Division equals 100 in Spot Numbers or 10 Inches in Rainfall. Actual Rainfall at each Station is Indicated by Figures on Left of Diagram.

as the stations of Central Australia, but may be regarded also as a coastal station, and its rainfall relation to the sunspot curve is thus rendered more complex. Its smoothed winter rainfall curve has a coefficient of $+0.32$ with probable error of ± 0.067 when correlated directly with the sunspot curve, and $+0.21$ when compared with the sunspot figures of three years earlier. Inspection of the curves suggests a rainfall lag for the maximum rainfall, but not for the minimum rainfall. I accordingly tried correlating this rainfall with the sunspot curve modified systematically, so as to throw the maximum sunspottedness about two years later. This gave a coefficient of $+0.37$, probable error ± 0.061 . The modification was accomplished by joining with a straight line the point for the third minimum year with a point midway between the points for the fifth and sixth years following. This point was substituted for that of the fifth year. Assuming a three-year lag, Powell's Creek gave $+0.44 \pm 0.078$, and Tennant's Creek $+0.23 \pm 0.091$. These correlations suggest that Bendigo and Daly Waters respond most completely to sunspot activities, the former immediately, and the latter with a lag of four years, and it seems probable that other stations follow one or both of these.

It may be remarked that the use for correlation purposes of the winter six months' rainfall of the inland stations of the south-east quarter of the continent is justified economically, but, from inspection of the curves, it is obvious that it matters little whether the winter or annual rainfall is taken. The winter rainfall is dominant for this area.

Average annual rainfall variations with Sunspot Cycle.

Very interesting results are obtained by grouping the rainfalls of the more important long-record stations, in accordance with the sunspot periods, and obtaining the mean rainfall for each year of the sunspot cycle. As Bendigo may be taken as typical of all Northern Victoria, and has the longest rain record of any such station, I began with that.

The following table and figure 2 show the arrangement and mean results. As we have practically six complete cycles, we get, except in the case of the twelfth year, the records of six years to determine the mean rainfall for each year of the sunspot cycle. From the first to the fourth year, when the sunspottedness is usually at its maximum, the rainfall is rising to its maximum. Then the rainfall begins to decline, not regularly, but so as to reveal drought tendencies every third year, or in the sixth, ninth, and twelfth years of the sunspot cycle, the last being much the worst. These drought years, with successive rain totals of 19.4, 17.0, and 14.0 inches, are so emphatically below the average rainfall, 21.4 inches, that

TABLE II.
RAINFALL IN RELATION TO SUNSPOT CYCLES.

Cycle Com'mencing Order in Cycles	1857		1868		1880		1891		1903		1915		Mean All Cycles	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
BENDIGO, ANNUAL RAINFALL.														
1	(2090)	2	1734	4	2237	3	1979	7	2810	8	1963	5	2136	4.8
2	(2450)	6	2154	3	1290	1	2685	8	1983	3	2880	8	2240	4.8
3	2180	5	3837	8	2162	5	2109	3	1912	4	3011	7	2535	5.3
4	2530	5	2712	5	2178	6	2881	10	2746	8	2195	6	2540	6.7
5	2820	10	2625	6	2180	5	2091	5	2102	5	1625	4	2240	5.8
6	1850	4	2054	5	2016	5	1625	3	1592	3	2511	6	1941	4.3
7	3392	9	1958	3	2139	5	1867	3	2392	6	2633	8	2397	5.7
8	2303	8	2482	7	2625	7	1967	2	2295	7	1384	1	2176	5.3
9	1085	1	1400	3	1238	1	2175	5	2321	6	1977	4	1699	3.3
10	2141	7	1696	4	2829	7	2033	6	1587	4			(2096)	(5.6)
11	2666	5	2044	3	2485	4	1534	4	2009	3			(2148)	(3.8)
12			1637	4			1350	2	1211	2			(1399)	(2.7)
Means	2280	5.6	2194	4.75	2125	4.5	2029	4.8	2080	4.9		3.8		
BENDIGO, WINTER RAINFALL.														
1	835	1	981	2	901	0	1101	3	1592	4	1645	5	1176	2.5
2	1029	2	1442	2	811	0	1859	5	1307	2	2145	5	1432	2.7
3	1381	4	3002	6	1187	3	1598	2	1381	3	2315	5	1811	3.8
4	1313	2	1402	1	1569	4	1934	6	1973	5	1400	3	1597	3.5
5	1557	4	1729	3	1121	2	875	1	942	1	819	1	1174	2.0
6	1423	3	1195	2	1068	1	708	0	1212	2	2062	5	1278	2.2
7	1931	6	929	0	1222	3	1277	2	1743	3	1693	5	1466	3.2
8	1273	4	1683	4	1296	3	1413	1	1481	4	1027	1	1362	2.8
9	782	1	917	2	923	0	1169	1	977	2	1770	4	1090	1.7
10	1390	4	875	2	1683	4	1263	3	1080	2			(1258)	(3.0)
11	2149	4	827	0	1652	3	1072	3	1046	1			(1349)	(2.2)
12			1013	2			591	0	321	0			(642)	(0.7)
Means	1369	3.2	1333	2.2	1221	2.1	1238	2.25	1255	2.4	1653			
DAILY WATERS, ANNUAL RAINFALL.														
1	—	—	—	—	2244	—	1218	—	2187	—	1886	—	1889	—
2	—	—	—	—	1897	—	1815	—	4595	—	2557	—	2716	—
3	—	—	—	—	3117	—	2087	—	1906	—	2545	—	2418	—
4	—	—	—	—	1581	—	2961	—	1687	—	2598	—	2207	—
5	—	—	—	—	2825	—	2538	—	2621	—	2137	—	2780	—
6	—	—	4391	—	2406	—	3921	—	2496	—	2204	—	3084	—
7	—	—	3272	—	2927	—	1913	—	1753	—	3878	—	2749	—
8	—	—	3603	—	3584	—	2977	—	4325	—	3575	—	3613	—
9	—	—	2552	—	2023	—	3288	—	2444	—	2484	—	2558	—
10	—	—	4248	—	2905	—	899	—	1811	—		—	2216	—
11	—	—	2358	—	3289	—	2658	—	1648	—		—	2488	—
12	—	—	3509	—		—	1966	—	2074	—		—	2516	—
DENILQUIN, ANNUAL RAINFALL.														
1	—	—	1269	—	1459	—	2147	—	1605	—	1315	—	1559	—
2	—	—	1328	—	1362	—	1691	—	1452	—	1933	—	1553	—
3	1327	—	2405	—	1507	—	1518	—	1369	—	2508	—	1772	—
4	1833	—	2077	—	1482	—	2408	—	2732	—	2033	—	2102	—
5	1510	—	1739	—	1090	—	1259	—	1116	—	1491	—	1367	—
6	1210	—	2254	—	1670	—	1188	—	1083	—	1653	—	1510	—
7	2538	—	1827	—	1394	—	1282	—	1521	—	1745	—	1718	—
8	1302	—	2414	—	2197	—	1391	—	1785	—	811	—	1650	—
9	871	—	1366	—	884	—	1390	—	1507	—	1641	—	1277	—
10	1489	—	1265	—	2607	—	1348	—	1950	—		—	1731	—
11	2058	—	2810	—	1805	—	1105	—	1254	—		—	1806	—
12		—	1428	—		—	1113	—	554	—		—	1032	—

NOTE.—The figures in columns "A" represent rainfall in points (1 point = .01 in.); those in columns "B", the number of months with rainfall above normal.

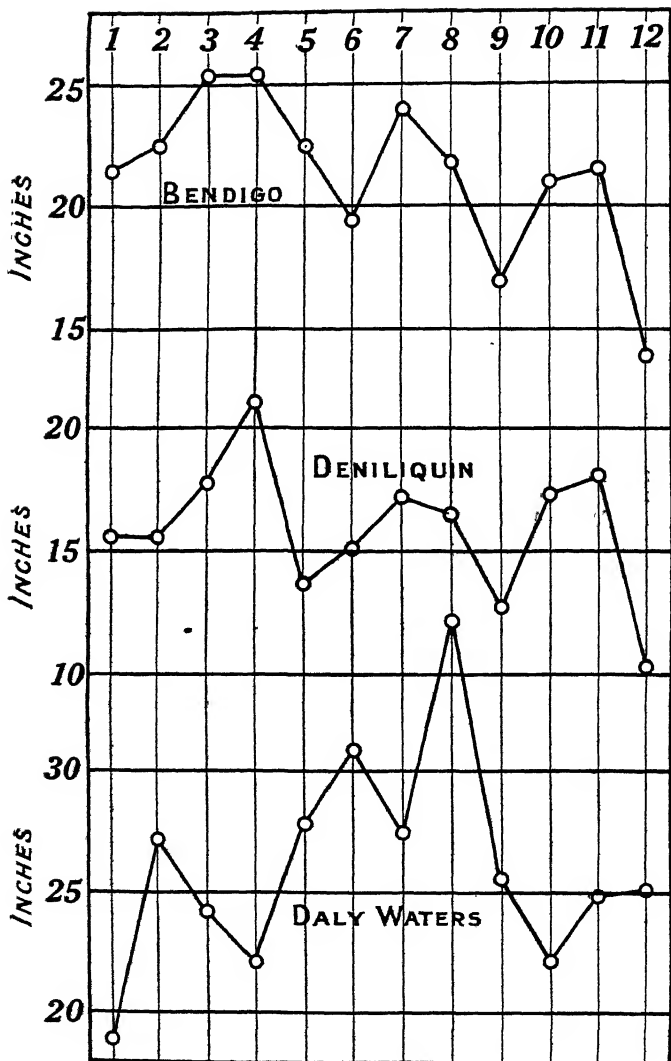


Fig. 2.—Rainfall Variation during Sunspot cycle.

one can hardly help concluding that we have here made evident the operation of a three-year cycle. As, however, it is not apparent during the rising phase, it is natural to conclude that the increasing solar activity is such as to cause a sort of forced oscillation, after which terrestrial influences become manifest in a three-year period. To show whether these results really represent the rainfall characteristics of the various years, I counted the number of months in each year with rainfall above normal, and took out the means. These well support the rainfall means, but are a little more emphatic in favour of the fourth year as the wettest. Taking the winter rains only (May-October), very similar results are obtained, but, according to them, the third year is slightly wetter than the fourth; and the fifth year slightly drier than the sixth.

Treating the annual rainfalls from Deniliquin in the same way, we get the fourth year as the wettest, the fifth drier than the sixth, but both below normal, and the ninth and twelfth very dry. Its winter rains closely agree with those of Bendigo. Daly Waters gives equally striking results. Assuming a four-year lag, and placing its fifth year under the first of the sunspot cycle, we get a rainfall variation very much like that of the two preceding stations, but showing the tendency to a three-year period even more strongly—the first, fourth, seventh and tenth all being dry years. Such good agreements with solar activity as these results show might, of course, have been anticipated from the high correlation coefficients obtained between the rainfall and sunspot curves, but they are useful to indicate the probability of a three-year rainfall period as well as the eleven or twelve-year agreement with the solar period.

ART. XI.—*The Bacchus Marsh Basin, Victoria.*¹

By CHARLES FENNER, D.Sc.

(With Plate XVII)

[Read 9th October, 1924.]

- I. INTRODUCTION.
- II. THE EASTWARD EXTENSION OF THE GREENDALE FAULT.
- III. THE AGE OF THE GREAT VICTORIAN PENEPLAIN.
- IV. THE ROCKS OF THE BACCHUS MARSH BASIN.
 - (a) The Oldest Rocks.
 - (b) The Tertiary Leaf-beds.
 - (c) The Newer Basalt Sheet.
 - (d) The Alluvium of the Flats.
- V. THE RELIEF MODEL OF THE AREA.
 - (a) Data.
 - (b) Method of Construction.
- VI. PREVIOUS ACCOUNTS.
 - (a) General.
 - (b) T. S. Hart (1907).
 - (c) C. Fenner (1918).
 - (d) H. S. Summers (1923).
- VII. THE ORIGIN AND DEVELOPMENT OF THE BACCHUS MARSH BASIN.
 - (a) The chief causative factors.
 - (b) The pre-Newer Basaltic valleys.
 - (c) The Newer Basalt Flows.
 - (d) The Basalt-dammed lake series.
 - (e) The Rowsley Uplift.
 - (f) The final stages of development.
- VIII. LIST OF REFERENCES.

I. Introduction.

The Bacchus Marsh area in Victoria has for many years attracted the attention of geologists. Beginning with remarks published by A. R. C. Selwyn in 1861, there has been an almost continuous series of papers and reports regarding this area, no fewer than 84 important references being included in the latest bibliography of Bacchus Marsh Geological literature (1). While most of this deals with the geology of the area, there has been,

1.—Read at the Adelaide meeting of the Austr. Assoc. Adv. Sci., held in August, 1924.

during the past few years, an increasing interest in the complex physiographic features thereabouts.

Because of its economic importance, the Bacchus Marsh "basin" itself has invited special attention, and various opinions have been expressed regarding its mode of origin. None of these suggestions was published, as far as can be discovered, prior to 1907. In 1918, the writer gave some attention to this feature in a paper on the Physiography of the Werribee River Area (2, p. 297).

Although the Bacchus Marsh Basin is so well-known, being on the main road and rail routes from Melbourne to Ballarat, and being visited by practically every geologist whose duty or pleasure brings him to Victoria, a brief account of it may be here given. The Basin is of irregular shape, as shown in the generalised diagram herewith (Figure 1), and is situated in the north-west portion of the Port Phillip Sunkland, just east of the Rowsley Scarp (which bounds the eastern face of the Ballarat Plateau), and to the south of the Greendale and Gisborne scarp faces that mark the beginning of the northern highlands (the Lerderderg and Gisborne Ranges). Five streams meet within the basin, as shown in the figure; the Korkuperrimul, Lerderderg, and Pyrete coming from the north, and the Parwan from the south, while the Werribee crosses the area from west to east. West of the Rowsley Fault (shown by a broken line) the land is over 1000 feet in height, while the plains and hills that surround the basin are from 400 feet upwards, averaging little more than 500 feet. The floor of the Basin is about 200 feet below the level of the country immediately surrounding it.

In the latter part of 1922 the writer decided to develop his notes on this basin, for further publication; and as a preliminary step preparations were made for a relief model, on a scale of two inches to the mile, of the area around the basin, extending to the highlands west of the Rowsley Scarp. The completion of this relief map, from details kindly supplied for that purpose by the Commonwealth Military Authorities, occupied several months, and pressure of other duties subsequently prevented the further preparation of the paper.

In August, 1923, in the Excursion Handbook prepared for the Pan-Pacific Science Congress (1), Dr. H. S. Summers gave a comprehensive account of the geology and physiography of Bacchus Marsh. Special mention was there included of the basin and the flats, and a hypothesis regarding their mode of origin was put forward "with the object of arousing discussion on this difficult problem." The present paper, with the relief map of the area, is submitted as a contribution to this discussion. In addition, reference will be made to some points raised by Dr. Summers regarding the peneplanation and the faulting of the surrounding country, in so far as these matters are pertinent to the subject of this paper. Criticism may be advanced regarding the amount of detail here set out on this one physiographic feature, but the

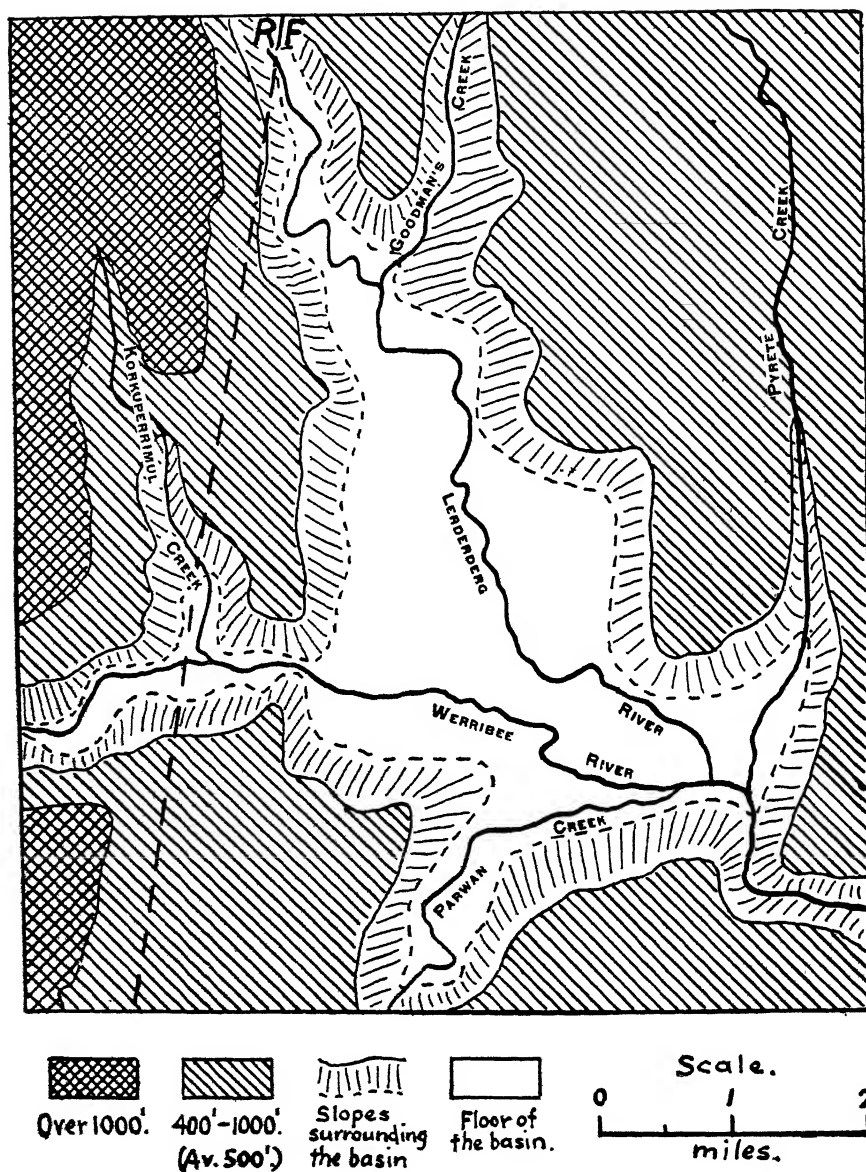


FIG. 1.—Diagram to show the general heights of the area, the positions of the streams, and the shape of the Basin. R.F. = Rowsley Fault.

wealth of evidence available, and the close bearing of the whole description on the Tertiary palaeogeography of Victoria, are thought to afford justification for such detailed treatment.

II. The Eastward Extension of the Greendale Fault.

Dr. Summers (1, pp. 98-99) points out that the writer, in his account of the Greendale Fault (2) does not deal with its continuance beyond the (later) Rowsley Fault. Careful review of original notes has failed to disclose any justification for this oversight. It is stated, however, in various places in the paper in question (2), that the fault or faults bounding the southern side of the Gisborne Highlands are possibly of the same age; these are in about the same alignment as the Greendale Fault.

The writer's conception is that the Rowsley Fault marks an old line of fracture, so that its influence on the Greendale fault is quite possible. Emphasis was given, in his description of the Greendale fault, to the south-eastern curve as it approached the Lerderderg; it is possible, however, that the Greendale fault bifurcated in the neighbourhood of the Upper Korkuperrimul, and that another branch of the fault continued more directly eastward, to join up with the Coimadai Fault (2, p. 236), and to die out to the eastward. The striking nature of the evidence along Robertson's Creek has perhaps led the writer to over-emphasise the south-easterly curve of the Greendale Fault; this curve brings the Greendale Fault to a tangential junction with the Rowsley Fault, and if the latter is really an ancient fracture line, of an age greater than that of the Greendale Fault, it is conceivable that this portion of the latter might there die out.

Dr. Summers also says (1, p. 99) that the writer "does not suggest any rejuvenation of the Lerderderg until the post-Newer Basaltic movements along the Rowsley Fault." Reference to the paper in question shows, however, that the greater age of the Lerderderg (apart from its pre-uplift existence) is clearly recognised. On page 206, for instance, is the statement: "In the Werribee area we have the Lerderderg, with its long and precipitous gorge, cut over 800 feet deep into very hard folded slates. . . . Meanwhile we have the Werribee, above Bacchus Marsh, cutting a gorge about 700 feet deep in quite similar rocks subsequent to the Newer Basalt period, presumably a much shorter time." The writer agrees with Dr. Summers in believing that uplift along the Greendale-Coimadai-Gisborne fault lines had taken place some time prior to the important happenings that played so great a part in the production of the present Bacchus Marsh topography—namely: The newer volcanic flows and the Rowsley uplift.

As a digression it may be here mentioned that, during the visit of the delegates to the Pan-Pacific Congress in 1923, while viewing the Werribee Gorge from above, Professors W. H. Hobbs and N. M. Fenneman, of U.S.A., expressed the opinion that, judged purely on the work done, they would regard the gorge as a Pleistocene feature. In view of our difficulties in Australia in correlating river work with geological time, this opinion is worthy of record.

III. The Age of the Great Victorian Peneplain.

In a discussion regarding the date of completion of the great Peneplain, the differential uplift of which has so largely determined our Victorian topography (2, pp. 202-212), the writer concluded that peneplanation was complete about the time of the Older Volcanic period, or "not younger than, say, Miocene." This is much earlier than the time suggested by most other Australian workers, excepting Hart (3).

Dr. Summers (1, pp. 97 and 108), suggests that the planation was completed at a still earlier period—the lower Tertiary; he would even put it so far back as "about the beginning of the Tertiary period." His conclusions are based on the age of the Tertiary leaf beds, clays, and lignites of Bacchus Marsh, with which he associates the lignite deposits of Altona Bay, the latter being overlain by marine Tertiaries (Balcombian). Dr. Summers holds that these leaf-beds, etc., are "post-fault"—that is, that they were developed subsequent to the first movements of relative uplift and depression that marked the completion (i.e., the destruction) of the peneplain.

The writer's conclusions (2) were based on the following facts:—

- (a) The Great Peneplain of Victoria was one which reached a remarkably complete stage of planation; this must have involved a very long period of still-stand, and as the erosive work in the very latest stages of a peneplaned area become almost infinitely slow, it is conceivable that the peneplain existed, as such, for a very long period indeed. In this case the most easily determined point in time that could be selected to mark the "completion" of the peneplain would be the commencement of those movements of relative elevation and depression that marked the new cycle of highland development.
- (b) The opening of the marine invasions of Victorian Kainozoic time are generally accepted nowadays as about middle Tertiary, which suggests that date as the opening of the new cycle of differential crustal movement.
- (c) Reasons have been put forward in some detail for associating these earliest post-peneplain crustal movements with the Older Volcanic period, and, while our knowledge of the age and the correlation in time of the rocks known as Older Basalts is admittedly imperfect, it still seems that there is sound reason for associating this period of vulcanicity with the first stages of the destruction of the peneplain.

The latest publications regarding the time relation between the Bacchus Marsh leaf-beds and the pre-Balcombian lignites of Altona Bay do not support the idea of their close association.

The writer therefore approached Mr. Frederick Chapman with a direct question on the matter, and received the following reply, which Mr. Chapman kindly gave permission to use. He says:—"I should certainly regard the Bacchus Marsh leaf-beds as younger than the Altona Bay lignite series. They (the leaf-beds) appear to represent the older part of the terrestrial phase marked out palaeontologically by the Deep Leads flora. I think they are therefore clearly Janjukian, and contemporaneous with the marine phase of the Batesfordian. The Older Basalt *in that area* (Bacchus Marsh) may represent the Lower Miocene; the blocking of the then existent river system may well be conceived as resulting in lakes and swamps, as suggested in Keble's paper on residuals." (4).

There is a vast amount of evidence to the effect that, about middle Tertiary times, there occurred in Victoria conditions that led to widespread and deep accumulations of fluvial, lacustrine, and estuarine deposits. The writer conceives that at that period the Great Peneplain had reached a stage of something more than advanced maturity—rather of an enfeebled old age—with numerous streams meandering across it, to die in wide, still lagoons and estuaries, or in broad swamps. There is evidence that the period was one of abundant rainfall, and that the relatively higher portions of the peneplain were thickly wooded. It is suggested, also, that the latest stage of the long period of still-stand that produced the Great Peneplain was merged into a very gradual and general movement of depression in south-central and south-eastern Victoria, and that with this depression are associated—

- (i.) The clays, leaf-beds, etc., of Bacchus Marsh.
- (ii.) The encroachment of the sea at Batesford, etc.
- (iii.) The enormous accumulations of lignites and associated sediments (Lal Lal, etc.).
- (iv.) The older volcanic period, and the Greendale-Gisborne uplifts.

In future efforts to determine the time of the earliest peneplain-destroying movements of uplift, particular attention might be given to the age of the Older Basalts of central and eastern Victoria, particularly those that cap various portions of the present highland area.

Reviewing the available evidence regarding the progress of the tectonic happenings of the Tertiary period in Eastern Australia, the writer suggests that the sequence was as follows:—Subsequent to the period of uplift that obliterated the Great Cretaceous Sea of Northern Australia, there was a long period of relative still-stand. This still-stand extended through the whole of the lower Tertiary period, and allowed for the completion of a very perfect peneplain, the whole of the eastern² half of the continent being reduced by sub-aerial erosion to an almost level surface.

2.—This great peneplain possibly included the whole of the present continent, but the eastern portion is here more particularly considered.

In early Miocene times portions of the peneplain were slowly depressed, particularly in the Bassian area, the Murravian Gulf, and the Great Valley of Victoria. Closely following these depressions, there commenced the epeirogenic movements that were destined to result in the formation of the great bow-shaped horst of the Eastralian Cordillera. This great arc is unsymmetrical about its point of greatest uplift, the Kosciuskan "plexus." The area of maximum upward movement is closely associated with that of maximum downward movement—the Bassian and other related sunklands. The rise of the great Eastralian horst and the formation of Bass Strait commenced in Miocene times. The first important uplift was in the neighbourhood of the Kosciusko plexus, and this movement, slowly extending to the northward and southward, continued with minor oscillations right on through the remainder of the Tertiary Period, culminating in a more intense phase in the early Pleistocene—the Kosciusko Uplift—associated with the Newer Volcanic period.

IV. The Rocks of the Bacchus Marsh Basin.

The general features of the geology of the basin, as far as such factors may have influenced the later physiographic development of the area, are set out in Figure 2. Although this area is one of the most closely mapped and most frequented by geologists in the whole of the State, difficulty was experienced in compiling this diagram, for the reason that previous workers have been most interested in the central and western portion. The detailed geology of the area where the River Werribee leaves the basin, as well as portion of the lower Pyrete Creek area, has never been published, as far as the writer is aware. The map published by Officer and Hogg (5) has provided portion of the geology of the lower Pyrete Creek, and Mr. W. Baragwanath, Director of the Victorian Geological Survey, has kindly procured and supplied some details of the rocks at the place where the Bacchus Marsh Basin narrows down to the steep-sided canyon whereby the river leaves the area.

The rocks dealt with here will be classified thus:—

- (a) Oldest Rocks.
- (b) Tertiary Leaf-beds, etc.
- (c) The Newer Basalt Sheet.
- (d) The Alluvium of the Flats

(a) *The Oldest Rocks.*—These are exposed in the north-west and north-east. They consist of Ordovician slates and sandstones, glacial sandstones and conglomerates, and older basalts. They are not specially involved in the problem under review, and need not be discussed in detail. The Ordovician slates that are so prominent in the lower Pyrete valley outcrop also in the Djerrirrh Creek, etc., to the eastward of the lower eastern margin of the area shown in Figure 2. A knowledge of the outcrops and the sub-Newer Basaltic levels of the Ordovician here would

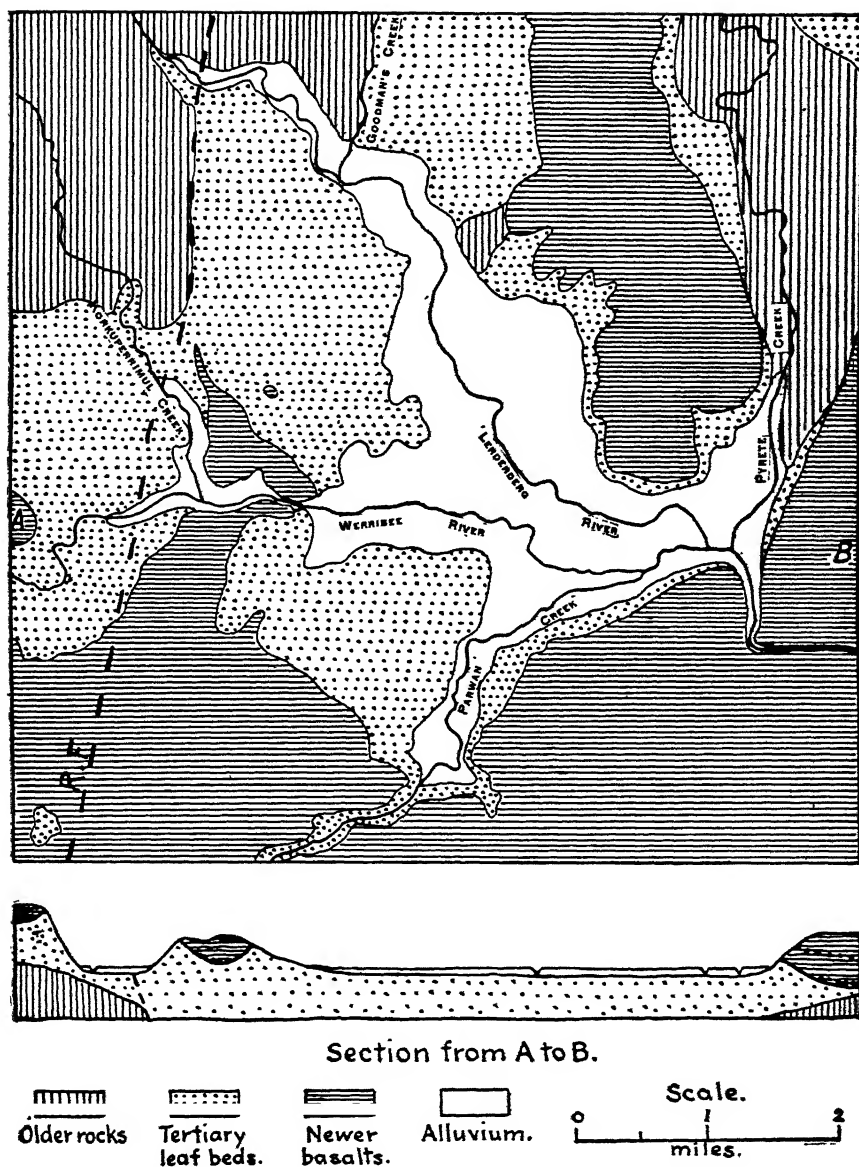


FIG. 2.—Plan and section to show the general geology of the Bacchus Marsh Basin.

possibly have an important bearing on this problem, but such information is not available. Ordovician slates outcrop within the Basin itself in the bed of the Lerderderg River, where it is

crossed by the road from Bacchus Marsh to Coimadai, at Darley. Geological maps usually show an area of Ordovician east of this point, extending up to the base of the Newer Basalt. and of such outline that it is difficult to harmonise same with the general relationships hereabouts. Officer and Hogg (5) give a quite different interpretation, and in an area where so many young geologists ramble, this small point is put forward for consideration. The glacial rocks are of Carbo-permian age, and the older basalts are (?) middle Tertiary. The folded Ordovician slates, etc., are highly resistant to erosion; the glacial materials vary in this respect, but may be classed as easily eroded; the older basalts are almost wholly decomposed, and are thus very readily eroded.

(b) *The Tertiary Leaf-beds*.—These have been abundantly described. In the area west of the Bacchus Marsh flats and east of the Rowsley Fault they are associated with, and have never been definitely separated from, a series of sands, gravels, and boulder beds that, as suggested by Dr. Summers (1), probably represent fault-apron material from both the Greendale and the Rowsley uplifts. The leaf-beds are soft, level-bedded (except where monoclined by the Rowsley Fault movements), and easily eroded, and have been an important factor in the formation of the Basin. They must have originally covered the whole of the area under discussion, and extended well beyond it. They occur throughout the Parwan Valley (2, pp. 278-281). The ease with which these beds are eroded attracted the attention of Wilkinson and Daintree when mapping the area (Quarter-sheet 12 N.E.) in 1868, and those workers suggested that this was due, in part, to the high percentage of soluble salts present in the beds, chiefly sodium chloride and magnesium sulphate.

(c) *The Newer Basalts*.—The newer volcanic sheet covers a considerable portion of the area; it was at one time much more extensive, but has been partly removed by erosion. The important part played by these basalts in the evolution of the present features will be developed later. They form a relatively thin sheet, being rarely more than 400 feet in thickness even where filling old depressions.

Some account should be given here of the geology of the south-eastern part of the area in Figure 2, where the Werribee River leaves the Basin. In the large eight-sheet geological map of Victoria, Ordovician rocks are shown as occurring in the river valley, underlying the basalt. When the writer last had an opportunity of visiting that portion of the area, some eight years ago, he did not realise the critical nature of the geological evidence there, and his notes do no more than indicate, in a general way, that the basalt extends right down to the bottom of the V-shaped valley of the river. In the absence of any detailed map of this part application was made to Mr. W. Baragwanath, Director of the Geological Survey, Victoria, for any information available, and in response thereto, provision was generously made for Mr. A. M. Howitt to pay a visit to the spot. Mr. Howitt's

notes show that two distinct flows of basalt are exposed in the valley walls, the first rock (upper flow) separated from the second rock (lower flow) by sand, gravel and wash. Mr. Howitt visited the south side of the river, adjacent to the Parwan railway station, and mentions that detached blocks of basalt occur in the bed of the Werribee just below the point of junction with the Lerderderg. The northern side was not examined, but the two flows appeared to be exposed there also, as observed from the opposite cliffs. Mr. Howitt's sketch shows neither Ordovician nor Tertiary (leaf-beds) in the narrow gorge of the Werribee. This information, which is very greatly appreciated, has been incorporated in the figures, etc., of the present paper.

The Newer Basalts, as well as any older rocks in this area, have in most parts been covered by wide sheets of fault-apron gravels, sands and silt. In order to simplify matters, these have not been shown in Figure 2.

(d) *The Alluvium of the Flats*.—Economically this alluvium is the most important formation of all; the flats embrace 4500 acres of rich soil. This has been deposited by the work of the five streams:—Lerderderg, Werribee, Korkuperrimul (Lyall's Creek), Parwan, and Pyrete (Coimadai Creek). In a previous description (2, p. 297), it was said that "the complex formations of the surrounding highlands, rich volcanics (older and newer), sandstones, clays, etc., all send their tribute to be blended together for the building up of the wonderfully fertile soil of 'The Marsh.'" In this description the writer failed to note the important fact that the Lerderderg, which has played such a large part in the work accomplished, derives almost the whole of its transported material from the poorest type of rocks in the area—the Ordovician slates and sandstones. The other streams concerned, particularly the Werribee and Korkuperrimul, have much richer and more varied gathering grounds. This has been brought under notice by the following facts.

When preparing the paper on the Werribee River area, the writer received important information concerning relative land values from the late Mr. Robert Dugdale, of Bacchus Marsh. This was incorporated in the paper referred to, with due acknowledgment. As both land and money values have so greatly altered during the intervening ten years, an effort was made to obtain a reliable estimate of present-day values of—

- (i.) The alluvial flats of the Basin.
- (ii.) The slopes surrounding the Basin.
- (iii.) The surrounding upland plains (mostly newer basalt) of Coimadai, Parwan, etc.

This information has been kindly supplied by Mr. Lawrence M. Dugdale, of Staughton Vale, Balliang. Mr. Dugdale's account is so interesting that liberty is taken to reproduce same in full:—

"The best land in the Bacchus Marsh basin does not change hands very often, as it is mostly settled by old families. I might mention that while in business at Bacchus Marsh we

noticed a big difference in the price of the flat land on the Werribee, and that on the Lerderderg River. The Werribee River flats are heavy, black soil, brought from the good lands of Myrniong and Ballan, and I would say an improved farm of these flats to-day would be saleable at from £120 to £150 per acre, according to situation; some small blocks right in the town of small area would bring as much as £180 to £200 per acre. The Lerderderg Flats we did not find quite as good, being more of a sandy loam from the hills of Blackwood and surroundings, and seemed to take more water, and were more subject to dry weather. A good farm on the Lerderderg would bring from £100 to £130 per acre. The bordering slopes are rather hard to value, some being good, others being wind-swept and bare; but I would say that from £9 to £12 per acre is a fair value; in some cases more, where the land is more sheltered. The plains of Coimadai, Rowsley and Parwan vary a good deal; where suitable for hay growing they are worth £12 to £14 per acre, but where they are a little stony and the soil showing more of a red clay, I would say from £8 to £10 was a fair value."

V. The Relief Model of the Area.

Data.—The Bacchus Marsh area has been, most fortunately, included in the sheets prepared and published by the Commonwealth Military Survey. The great importance of these sheets will be increasingly appreciated by geological and physiographic workers as the years go by, and will doubtless give a special stimulus to the carrying out of work within the areas mapped.

While the first sheets published were on a scale of one inch to the mile, with 50 feet vertical intervals, the sheet that includes Bacchus Marsh was published on a smaller scale—namely, half inch to the mile, and with 100 foot intervals. This is called the Ballan-Sunbury-Meredith-Melbourne sheet.

In the latter part of 1922, the writer applied to the Commonwealth military authorities for permission to use their published data in the construction of a relief map, and asked also for a copy of the area around the Bacchus Marsh Basin, on a larger scale, and with the 50 feet contours. The authorities generously granted permission to use their Survey Map for the purposes of this paper, and also supplied a detailed tracing of the area required, on the one-inch scale. The model made is based on this information.

Method of Construction.—Experience of unsuccessful efforts to make relief models without any previous hints or instructions, suggests to the writer the possible value of a brief note regarding the method used in making this model. The map on the one-inch scale was enlarged to a two-inch scale by ordinary methods; this drawing omitted all details not required on the relief map, and was

on tracing cloth. A number of blue prints of this were made, as many as the total number of contour lines involved.

The next step was to decide on the vertical scale—in this case 600 feet to the inch, about $4\frac{1}{2}$ times the horizontal scale. This amount of exaggeration was found most satisfactory, emphasizing the salient features of the relief, without making the model look unnatural. The vertical scale adopted in other cases must of course depend on the amount of relief involved and the area covered.

Having decided on the vertical scale, it was necessary to select a cardboard having the thickness required for one vertical interval (50 feet in this case). The blue prints were mounted on this cardboard, and with a sharp knife one of the cardboard sheets was cut to the shape of each respective contour line. This was a long and tedious work; but became easier with experience. The sheets were then superimposed in the proper order, the bottom one being fixed to a well-seasoned one-inch board, braced against warping. The sheets were fastened one to another with gum and small tacks (shoemaker's "tingles"). This made a permanent model which will stand any amount of usage. The "steps" between the contour lines of the various sheets were then filled in with plastic clay, which hardens on exposure. A mould was made from this model, and the casts turned out as required. For the successful completion of this model the writer is indebted to the generous assistance of Mr. R. M. Craig and Mr. J. A. Tillet, to whom his best thanks are due. It was originally intended to colour the model geologically, but owing to lack of time this proposal had to be abandoned.

VI. Previous Accounts.

(a) *General*.—As far as the writer is aware, no reference to the mode of origin of this Basin occurs in scientific literature before the year 1907. Conjectures were common, and one of these was that the Basin was tectonic in origin. This theory is incorrect, except in so far as faulting in the neighbourhood has had an important influence on the physiographic evolution. Mr. C. C. Brittlebank, the writer understands, long held the opinion that the Basin and Flats were formed by the "downstream cutting" of the Werribee and Lerderderg, working in the soft beds underlying the basalt.

(b) *T. S. Hart*, 1907, (3, pp. 268-9).—Hart briefly describes the formation of the Parwan Valley by the undercutting of the soft Tertiaries below the basalt sheet, with accompanying landslips, etc.; and continues: "A similar explanation can be applied to Bacchus Marsh itself. At the Marsh the valley has been cut through the basalt to the underlying tertiaries. Down stream deepening is less rapid because the hard rocks extend to lower levels and are not yet penetrated. Hence the valley has been greatly widened in the soft rocks."

Commenting on this account, which touches two of the most vital factors in the origin of the Basin, the writer has said (2, p. 299): "It appears that there are important differences in origin between the Parwan Basin and the Bacchus Marsh Basin, although the rocks worked in are closely similar. The Parwan Basin is on the upthrow side of the fault line (Rowsley Fault), with the accompanying rejuvenation of its streams. The Bacchus Marsh Basin lies on the downthrow side of the fault, where aggradational work would be done by the rivers, possibly until such time as the lower Werribee established a channel in the Newer Basalt. The Parwan Basin has been mainly accomplished by the headward erosion of steep tributary valleys. This can hardly have been the case with the Bacchus Marsh Basin."

(c) *C. Fenner*, 1918, (2, pp. 297-300).—In the pages mentioned the writer gave what he then considered was a reasonably full account of the mode of development of the Basin, with suggestions of perplexity as to the manner in which the formation was actually commenced. The causative factors then given were:—

- (i.) A bar of hard rock (the basalt filled valley of the ancient Bullengarook River) at the point where the Werribee now leaves the Basin.
- (ii.) Soft, easily-eroded rocks underlying the basalt sheet around the eastern and southern portions of the Basin.
- (iii.) The fact that five relatively important streams meet together in this area, doing most of the work by "side-swinging."

(d.) *H. S. Summers*, 1923, (1, p. 102).—The hypothesis put forward by Dr. Summers introduces a new factor, and one which provides a means of accounting for the actual *beginning* of the Basin, by mention of the fan delta accumulations of the Lerderderg River below the Greendale fault (or the equivalent eastward continuation of that fault scarp). Dr. Summers would appear to closely associate the Lerderderg fan delta materials with the Tertiary leaf beds, and whether this is accepted or not, his hypothesis throws a fresh light on the physiographic conditions that existed at the time of the newer basalt flows, and that played so great a part in determining the present features.

His remarks, with observations made by the writer in this area since 1918, and discussions of the subject with visiting physiographic workers, have stimulated the production of this attempt to give a detailed explanation of the progressive development of the physiographic features of Bacchus Marsh.

VII. The Origin and Development of the Bacchus Marsh Basin.

(a) *The Chief Causative Factors.*—These are as follow, arranged in a more or less chronological order:—

- (i.) The pre-Newer Basaltic topography.
- (ii.) The extent and outline of the Newer Basalt flows.
- (iii.) The convergence to this centre of five important streams.
- (iv.) The ease with which erosion could proceed in the soft Tertiaries underlying the basalt sheet.
- (v.) The existence of a hard bar of rock at the place that now marks the south-eastern limit of the basin.

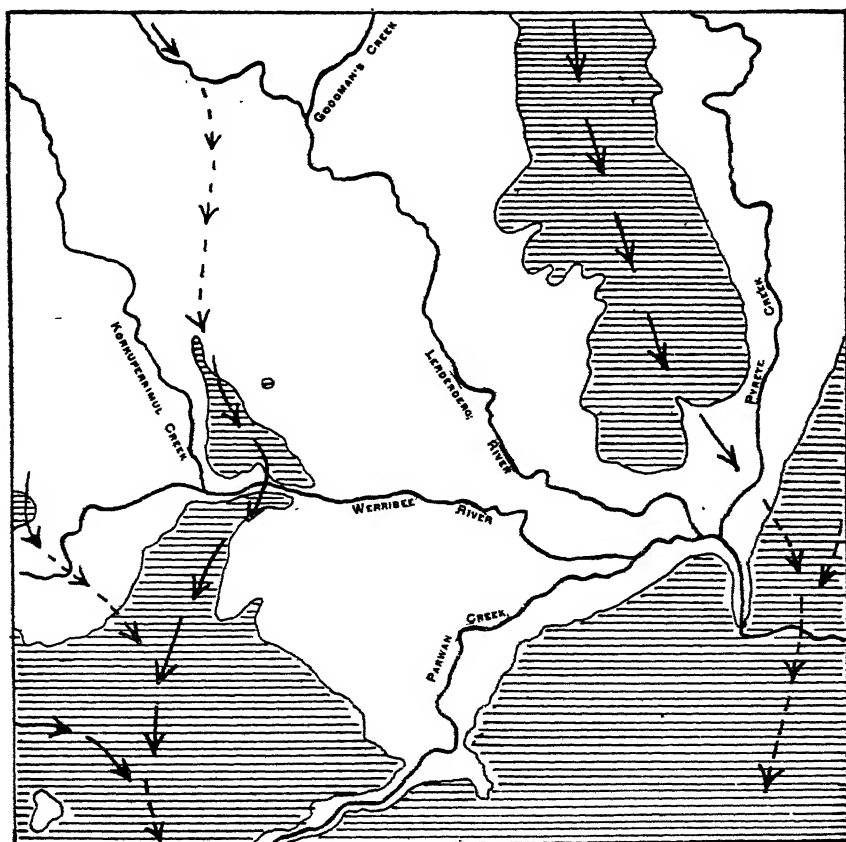


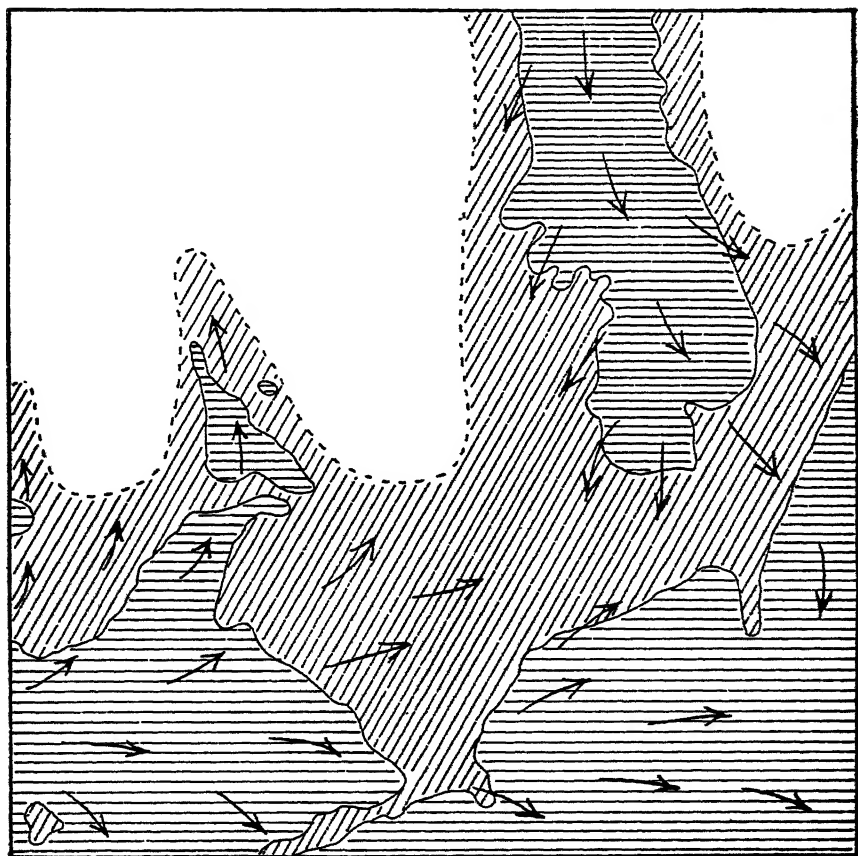
FIG. 3.—Diagram showing the present distribution of the newer-basalts and the present streams with the pre-basaltic valley system indicated by arrows. The present river system is shown in order that the relative positions might be more easily "placed."

(b) *The pre-Newer Basaltic Valleys.*—In the endeavour to arrive at a reconstruction of the pre-newer basaltic topography, the criteria adopted will be those outlined in previous work in this area (2, pp. 289-290). The conclusions regarding the sites of the ancient valleys are similar to those arrived at by the writer in the paper quoted, with one important addition.

These conclusions are set out in Figure 3. In this figure the present rivers are shown in order to enable the positions of the old streams to be more readily understood. The actual extent at the present day of the newer basalt occurrences is shown also, as these supply the main evidence for the reconstruction of the old valley systems here attempted. The pre-basaltic valleys are shown by series of arrows; these arrows are firm where the field evidence is definite, but are shown dotted where the evidence is so far incomplete. The system was as follows:—

- (i.) In the south-west corner of the area shown in the figure is a portion of the "Ancient Werribee River," flowing east and turning to the south.
- (ii.) A little to the north is the small tributary that, since the evidence therefor occurs in the basalt cap of the present Trig Hill, we may call the "Trig Hill Tributary."
- (iii.) To the north-east of this a valley came down from the northward, and was basalt-filled up to a point close against the well-known Bald Hill. For the time being we may refer to it as the "Bald Hill Tributary."
- (iv.) Further to the east, and coming also from the north, we have the long valley of the Ancient Bullengarook River. This description does not altogether agree with the account of this ancient river as set out by Officer and Hogg (5, p. 67).
- (v.) There remains the fact that there existed at that time a large and important stream, the modern Lerderderg, rejuvenated by the Greendale and Gisborne line of uplifts, and, in the extreme north of the area shown in Figure 3, undoubtedly occupying the same valley or gorge that it flows in to-day. The probability is, as pointed out by Dr. Summers, that large fan deltas were deposited by this river below the fault scarp, particularly in the north central part of the area shown. The lower valley of this river must have been in part basalt-filled at the time of the volcanic outpourings. There is no trace of the cross section of such a valley, as far as is known, in any part of the walls of the Basin (see plan of geology, Fig. 2). After a careful consideration of the present heights, and the available geological evidence, the conclusion is reached that the "Bald Hill Tributary," represents portion of the Ancient Lerderderg Valley.

This gives us a fairly complete conception of the pre-newer basalt landscape. The surface was one of low relief, and must have been but little above sea level; the shallow valleys shown were for the most part in the soft level-bedded Tertiary sands, gravels, and mudstones. Low highlands of older and harder rocks existed to the north, above the Greendale-Gisborne fault scarps, but the area with which we are dealing consisted of the fluvatile, etc., deposits laid down under the conditions described in a previous section (Section III.). In the intervening period they must have been preserved by the movements of depression that accompanied their accumulation, but were now sufficiently



Present extent
of basalt.

Probable original
extent of the lava.

→ Direction of
Lava flow.

FIG. 4.—Diagram to show the original extent of the newer basalt, and the direction of movement of the lava flows.

uplifted for the formation of the shallow valleys now partly preserved below the newer basalts.

(c) *The Newer Basalt Flows*.—It is thought that the most effective way to outline this account of the gradual development of the physiography would be by means of a series of progressive plans, with descriptions. These plans will serve the twofold purpose of giving definiteness to the descriptions, and of allowing for more exact criticism or confirmation in the light of such other evidence as, now or later, may be brought forward. Ideally, sufficient of these diagrams should be drawn to enable a cinematograph record to be made, but in this case, the number is reduced to six (Figures 4 to 9 inclusive). It is not suggested that any one of these diagrams represents the actual conditions at any set time. They are intended to represent processes rather than products.

We know from the evidence of the levels of the basalt surface, and from the numerous sections exposed, that there were two main flows in this area, one eastward along the Ancient Werribee, and one southward along the Ancient Bullengarook. These in part overflowed the valleys and spread out in thin sheets. There is no evidence that any centres of effusion of lava existed at the heads of the Trig Hill Tributary, or of the basalt filled portion of the Lerderderg Valley. In addition the relationships between the levels at these places and those of the main flow suggest that their basalt-filling came upstream from the south.

Summing up, we have the position shown in Figure 4. This would suggest a special accumulation of lava where the two flows met, in the south-east of the area. It is probable also that the surface junction between these flows gave direction to the first valley of the post-basaltic Werribee over the surface of the lava. We do not know the relations in time between the Bullengarook lava flows and the Werribee lava flows, but it seems safe to assume that they were so close that the actual sequence does not affect the present discussion. There is no evidence regarding the outer limits of the lava in the central portion of the area shown in the figure, but from a consideration of the probable outline of the Lerderderg fan delta, and by analogy with the margins of the basalt sheet in other parts of the State, under somewhat similar conditions, the boundary was drawn as shown.

(d) *The basalt-dammed lake series*.—With the oncoming of the basalt flows (Figure 4) to the stream system shown in Figure 3, one of the immediate results would be the formation of a series of crescentic lakes or swamps. An attempt to show this lake system is made in Figure 5. For convenience in exposition it is here assumed that the newer basalt flows wholly antedated the uplift along the Rowsley Fault. The streams are in this figure given the name of their modern representatives. The lake that was formed by the Korkuperrimul is called Lake Lyall, from the alternative name of that creek; that formed by the Lerderderg and Goodman's Creek is called Lake Lerderderg; and that

formed by the Upper Pyrete is called Lake Coimadai, from the alternative name of that stream. No effort is made to represent the actual extent of the lakes, but it is possible that in an area of low relief, the effect of the basalt banks would be to form lakes more extensive than those shown in the figure. Each of the lakes would develop an overflow outlet, at first somewhat swampy and ill-defined, over the basalt sheet.

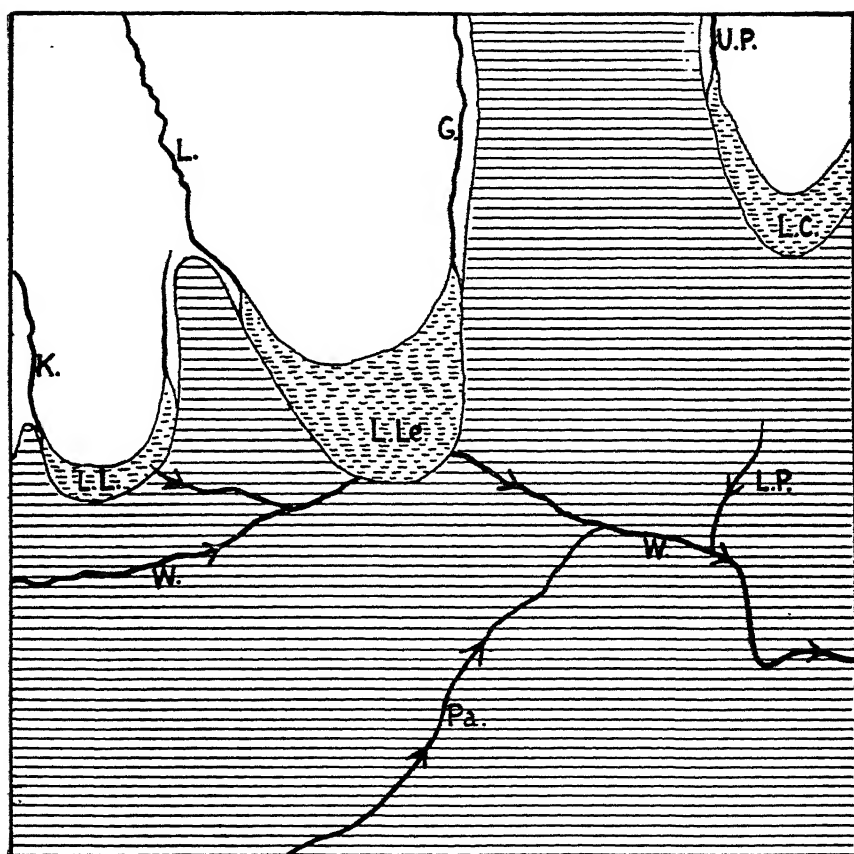


FIG. 5.—Diagram to show the series of lakes formed by the newer-basalt flows. L.L. Lake Lyall; L.Le. Lake Lerderberg; L.C. Lake Coimadai; K. Korkuperrimul; L. Lerderberg; G. Goodman's; U.P. Upper Pyrete; W. Werribee; Pa. Parwan; L.P. Lower Pyrete.

Lake Lyall.—This lake was formed by the Korkuperrimul, between the Trig Hill and Bald Hill basalt tongues. It would probably overflow to the south-east, and would, in common with the other lakes, be subject to fairly rapid silting-up. Doubtless,

"twin streams" were developed on the two sides of the Trig Hill basaltic tongue, and also of the Bald Hill basaltic tongue. The two central streams would, in the soft rocks thereabouts, migrate towards one another to form the present Korkuperrimul Valley.

Lake Lerderderg.—It cannot be determined whether, after the basalt flow, the main Lerderderg River took up its course on the eastern or the western side of the Bald Hill basalt tongue. If on the western side, however, the Rowsley uplift would have diverted it to the eastern side, and it is therefore diagrammed as forming the large lake between the Bald Hill basalt tongue and the Bullengarook basalt tongue. The fact that the Werribee exists where it does to-day, in the western part of this area, in a gorge deeply cut through the basalt, implies the existence of a stream in about that position in the period represented in Figure 5. It is assumed to have flowed into Lake Lerderderg, but whether it did so right from the beginning is immaterial. The Bullengarook basalt tongue gave rise to the twin streams of Goodman's and Pyrete Creeks. Of these, the Goodman flowed into Lake Lerderderg.

Lake Coimadai.—The Upper Pyrete, lateral to the Bullengarook flow, was dammed by the same basalt sheet that gave it birth; this seems clear from the present levels and extent of the basalt sheet (Fig. 2). It appears to the writer that the lake formed by the Upper Pyrete presents features of much greater interest than do the other two lakes, on account of the explanation it may afford of some hitherto puzzling facts.

For many years the limestone deposits of Coimadai have attracted interest on account of their economic value, and their fossil content of mammalian bones. But their existence has never been satisfactorily accounted for, nor their relation to the newer basalts determined. In developing his theory of the formation of these lakes, the writer was struck by the manner in which the accounts of the Coimadai limestones fitted in with the theory of the post-basaltic Coimadai Lake.

That there was a basalt-dammed lake or swamp in this locality cannot be doubted once the facts are brought under notice. In their account of the Coimadai limestones, by Officer and Hogg (5, pp. 63-65), these limestones are described as lacustrine, and as being interbedded with and overlain by a series of sands, gravels, and conglomerates. They contain the remains of extinct marsupials, with undescribed plant relics. Interbedded with them are beds, up to 6 inches thick, of volcanic ash. The age has been suggested as Upper Pliocene to Pleistocene. All these facts fit in with the conditions here outlined from the point of view of physiographic development.

Messrs. Officer and Hogg considered that the lake, in which these limestones and sediments were deposited, was pre-basaltic in age, and that it extended over the whole Bacchus Marsh area—the limestones being deposited in a somewhat sheltered Coimadai

Bay. The writer considers that the present account fits in more closely with the known facts. A consideration of the relative levels suggests that the Coimadai limestones were deposited in a deeper part of the lake, possibly where a tributary valley of the ancient Bullengarook had been left unfilled by the basalt flow. Officer and Hogg's reference (p. 65) to the occurrence of similar limestones within the Bacchus Marsh basin suggests that similar chemical deposits were formed in Lake Lerderderg.³

The remaining features of Figure 5 are the young stream courses on the basalt sheet, in the south-eastern part of the area. The Werribee is there assumed to have taken up a course along the line of junction of the two separate basaltic sheets (Fig. 4). The course of the Parwan is assumed to have been somewhat in the position it occupies at present, though it is possible that this stream originally flowed south, to the west of Bald Hill, and was later captured by the headward erosion of a small stream formed as the Basin was deepened (see Commonwealth Military map of the area). A small stream, destined to become the lower Pyrete, is assumed to have arisen where shown on Figure 5; the nature of the basalt flows suggests that Lake Coimadai may have overflowed eastward to the Djerriwarrh Creek, and this lake may have existed long after the other two here mentioned had disappeared.

(e) *The Rowsley Uplift*.—It is assumed, for purposes of clarity, that the Rowsley uplift was, in this area, wholly post-newer basaltic. There is evidence that the assumption is correct. However that may be, the important fact is that there was, about this time, an uplift of that portion of the area west of the Rowsley Fault (shown by a broken line in Figure 6). One effect of this would be the destruction of Lake Lyall, and the commencement of strong headward erosion, from the fault scarp, along the Lerderderg, Korkuperrimul and Werribee, where these streams cross the fault line. A bracket-shaped mark thus [, on these and other streams in these figures, is meant to indicate vigorous headward erosion.

In this figure, the lakes are assumed to have quite disappeared. The stream leaving Lake Lerderderg would soon cut through the basalt sheet, which would be very thin towards its margins. As soon as a definite channel had been cut by these streams, they would be in a condition for doing fairly vigorous work during flood times, having an abundance of grinding tools from the various fan delta gravels, etc.

As the valleys deepened in the basalt sheet itself, the soft underlying Tertiaries (leaf-beds, etc.), would be reached. In these erosion would be very rapid, the basalts would be undercut, and

3.—Since writing the foregoing, the writer has had the opportunity of reading "The Geology of the Coimadai Area" by Arthur L. Coulson, M.Sc. (Proc. Roy. Soc., Vic., Vol. XXXVI (N.S.), Part II., 1924). Mr. Coulson has investigated in detail the problem of the Coimadai Tertiary limestones, and arrives at conclusions (pp. 171-174) somewhat similar to those set out above, but considers that the lake in which the limestones were laid down was already in existence, in part, at the time of the outpouring of the Bullengarook lava flow.

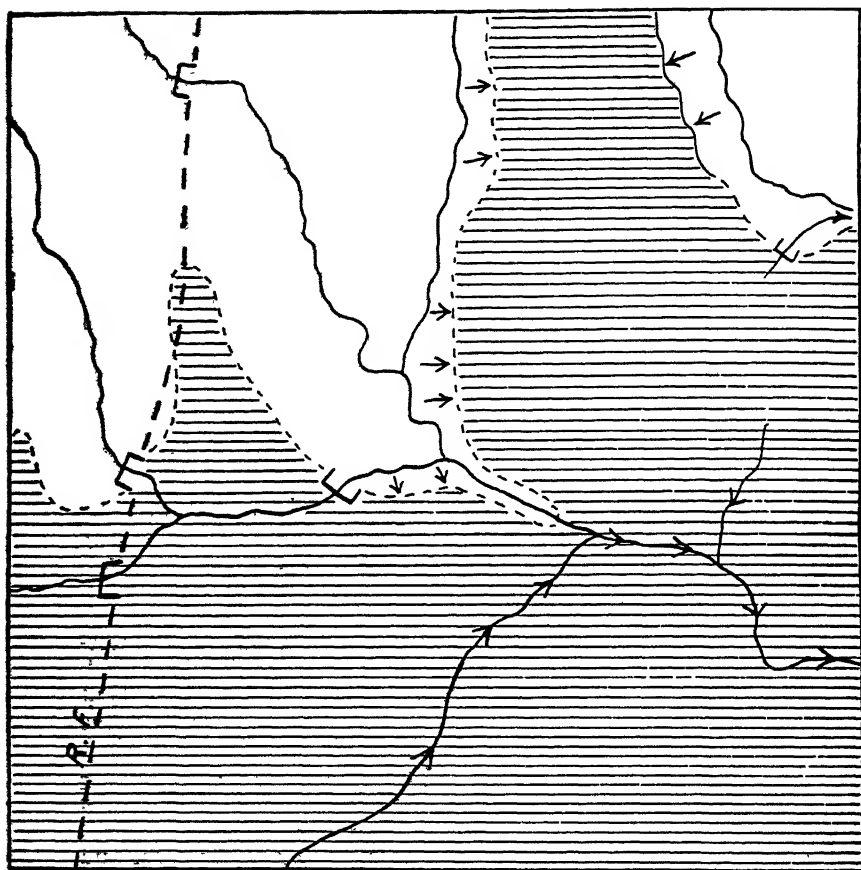


FIG. 6.—Diagram to show the conditions obtaining at the time of the Rowsley Uplift. The fault line is marked R.F. Other marks indicate the nature of the work being done by the rivers, as described in the context.

thus their disintegration and removal hastened. Where the river bed was still in basalt the whole energy of the stream would be concentrated on the downward deepening of its channel. Upstream, where the soft underlying Tertiaries had been reached, there would be much side-swinging, with active attacks on the walls of the embryonic Bacchus Marsh Basin (see arrows, Fig. 6).

In Figure 6, et seq., the chief activities of the streams are indicated by signs, as follows: The sign [indicates headward erosion; the small arrows indicate side-swing erosion and consequent valley widening; the arrowhead on a stream indicates downward cutting.

(f) *The final stages of development.*—The subsequent stages of development are set out in Figures 7, 8, and 9, and, with the

various symbols to indicate headward erosion, downward cutting, and valley widening, these figures should convey the writer's idea of the progressive stages of physiographic evolution much more definitely than many pages of verbal description.

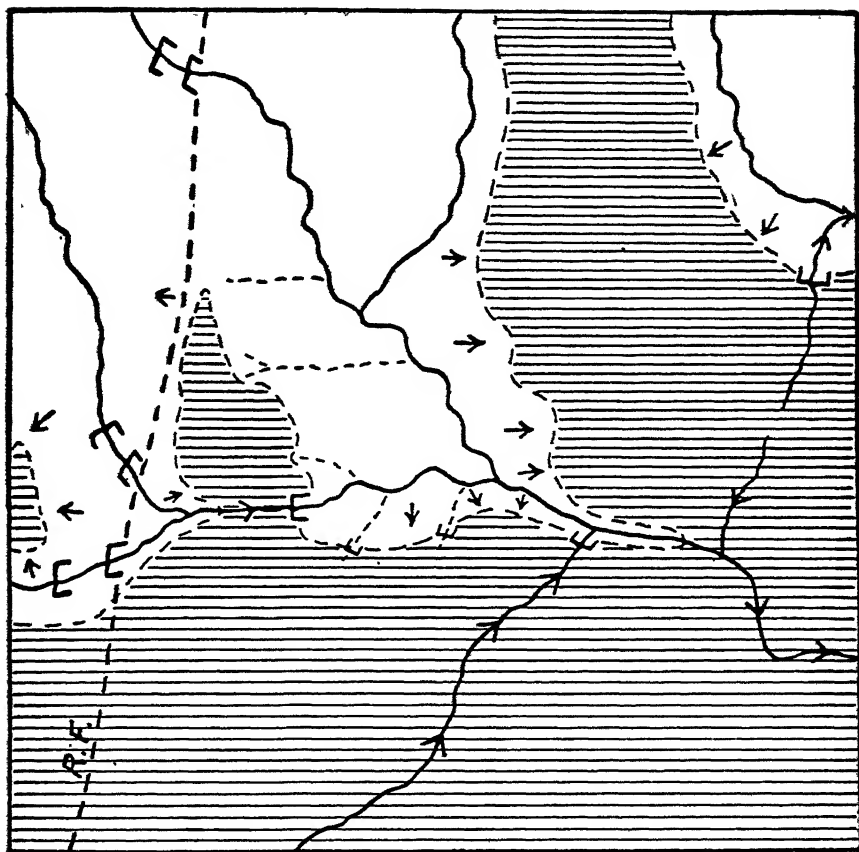


FIG. 7.

Figure 7 represents a further stage. The basalt tongue of the Bald Hill tributary led to the formation of a narrow gorge in the Werribee, where the latter stream crossed the tongue—a gorge that is even to-day distinctly in evidence. The result is a small edition of the Bacchus Marsh flats caused by the swinging of the streams above this bar (see Figure 1). Throughout the paper these flats have been regarded as part of the Bacchus Marsh Basin. The Trig Hill basalt tongue is rapidly disappearing. The Bald Hill tongue is subjected to much less erosive attack, and has not greatly diminished in size; it is in part protected by the accumu-

lation of "fault apron," material. The young Bacchus Marsh Basin is growing, and the basalt sheet has been cut through, in a downstream direction, so that the mouth of the Parwan may now be regarded as within the Basin, that is, it is in the area where it can commence work on the soft Tertiaries. Goodman's and Pyrete Creeks are deepening their valleys, and migrating side-wards away from the basalt tongue that divides them.

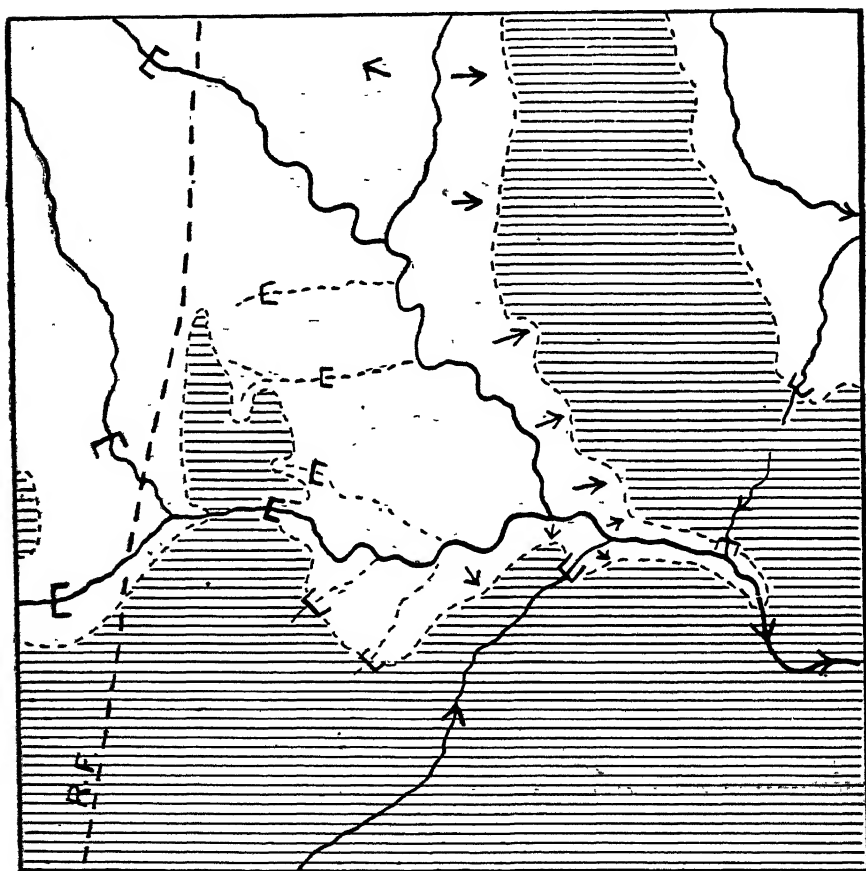


FIG. 8.

The processes shown in the last figure are continued in Figure 8. By downstream cutting the Werribee has now included the Lower Pyrete in the "soft rock" area, and that stream may now commence the headward erosion that will ultimately enable it to capture the Upper Pyrete, which is, at the stage here shown, flowing into the Djerriwarrh Creek. The Parwan is now assisting in extending the area of the Basin by headward erosion, and the

west and southern slopes are pictured as being attacked by small streams. There is some uncertainty regarding the exact present-day margin of the basalt on the west and south of the Basin, owing to the accumulation of scarp face alluvial that occurs there.

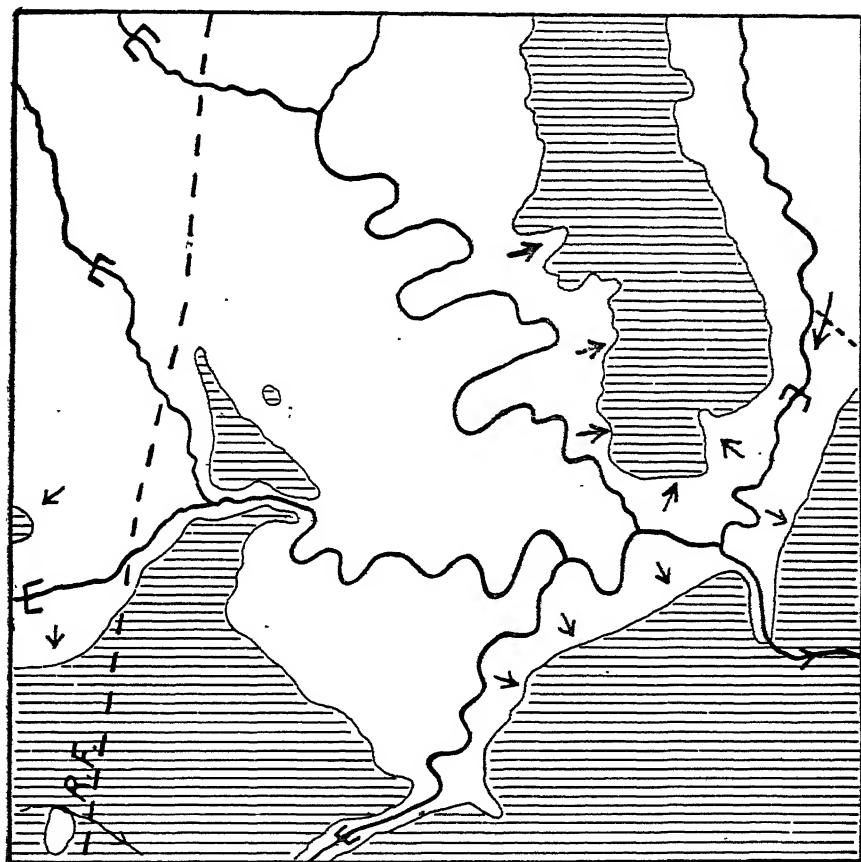


FIG. 9.

In Figure 9, the conditions shown are intended to represent the position just prior to the present day. The margin of the basalt sheet is drawn as it is to-day (compare Fig. 3). The four main streams within the basin are vigorously widening their valley in the soft Tertiaries, the Upper Pyrete has been brought in by capture, and the parent stream (Werribee) has reached the deeper basaltic bar of the ancient Bullengarook Valley. It will be noted that the extension of the Basin is set out as being much greater than at any previous stage; this is intended to indicate the

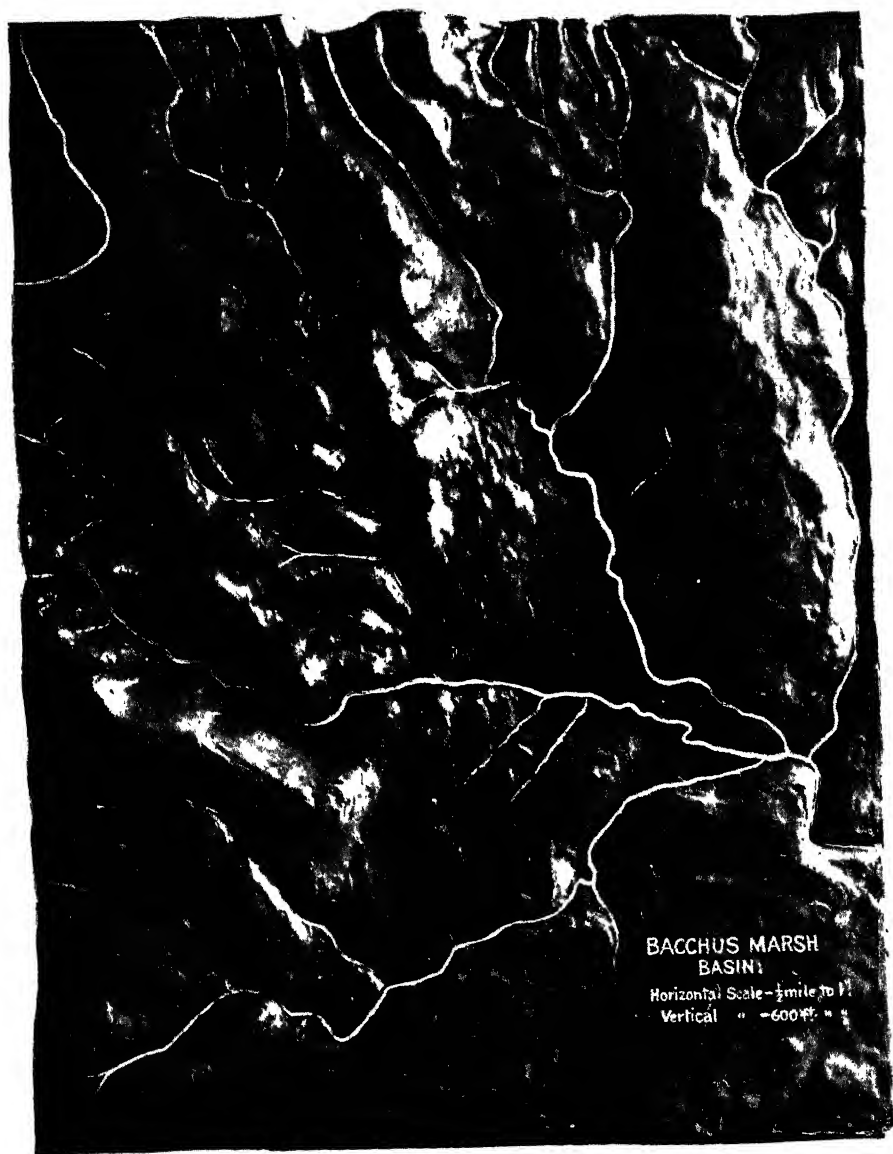
influence of the Bullengarook basalt tongue—or whatever deeper bar of basalt has been met by the Werribee at the south-eastern limit of the Basin. The “holding-up” of the river in this gorge has led to an enormous amount of upstream sideswinging and valley widening, with the formation of the wide flat-floored valley known to us as the Bacchus Marsh Basin.

Few cases of marked valley-widening above a bar have been recorded for Victorian streams, but there are some well-known examples, notably the Wando and Wando Vale Ponds above the bar of the Hummocks in Western Victoria.

Dr. Summers has mentioned (1, p. 111), as the last stage of geographical evolution here: “Recent deepening of the Werribee Valley below Bacchus Marsh basin, and the consequent dissection of the alluvial flats by the Werribee and Lerderderg Rivers.” It is true that the various streams that built up these alluvial flats are now apparently engaged in destroying them. It may be that this is a normal phase of the basin’s history. Rivers as a rule build up their bordering alluvial flats during heavy floods, when the silt-laden waters overflow and spread widely over the surrounding country, just as is the case along the Murray River to-day, or along those of Gippsland rivers that are so busily filling up the Gippsland Lakes. The coming of man, with his systems of drains and snagging of streams, lessens the number and extent of the widespread floods, and causes a concentration of the river action to one defined bed. Two things suggest that this downward cutting of the river beds into the alluvium, with attendant undercutting, etc., has been accentuated since the settlement of the Basin: First, there is the fact that the early settlers gave the locality the name of *Bacchus Marsh*, and secondly, there are swampy areas marked on early maps, where now the streams run in steep-sided channels through tilled fields. When we consider the swinging of streams in soft alluvium, with destruction of roads and other man-made contrivances, there is a strong tendency to think in terms of historical time, rather than of geological time.

If the present economically serious downward-cutting and side-swinging in the alluvium at Bacchus Marsh is to be correlated with the general evidence of recent minor uplift, that is to be found along our coasts, then it must be agreed that such uplift has first led to a deepening of the outlet gorge of the Werribee Basin. It is certainly worthy of note that, apart from a few cases locally explainable, the most marked feature of present-day stream activity throughout the various States appears to be a vigorous downward cutting into alluvial accumulations.

To return to the case of the Bacchus Marsh Basin, it is suggested that its extension is being carried on to-day in much the same manner, and at a somewhat similar rate, as have prevailed during the long period of its development.



Photograph of relief model of the Bacchus Marsh Area.

VIII. List of References.

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3. Hart, T. S. "The Highlands and Main Divide of Western Victoria." *Proc. Roy. Soc. Vic.*, n.s., xx. (2), 1908, p. 250.
4. Keble, R. A. "The Significance of Lava Residuals," etc. *Proc. Roy. Soc. Vic.*, n.s., xxxi. (1), 1918, p. 129.
5. Officer, G., and Hogg, E. G. "The Geology of Coimadai, Part I." *Proc. Roy. Soc. Vic.*, n.s., x. (1), 1897, p. 60.

EXPLANATION OF PLATE.

Photograph of relief model of the Bacchus Marsh area.

ART. XII.—*Monograph on Australian Fossil Polyplacophora*
(*Chitons*).

By EDWIN ASHBY, F.L.S.

(Communicated by J. A. Kershaw, F.E.S.).

(With Plates XVIII.-XXII.)

[Read 11th December, 1924.]

I am indebted to the National Museum, Melbourne, Victoria, for the present opportunity of examining a number of fossil Polyplacophora, many of which were personally collected by Mr. Frederick Chapman, Palaeontologist to the Museum; to Mr. Francis A. Cudmore, for the loan of many specimens collected by himself, as well as others that had been collected by the late Dr. T. S. Hall; to Mr. F. A. Singleton, for help in many directions, and in particular for supplying the exact localities and horizons; to the University of Adelaide and to the widow of the late Mr. E. D. Atkinson for the loan of many types; and to Prof. Harvey Johnston for loan of literature. It was originally intended to limit this paper to a description of the fossil Polyplacophora in the National Museum, Melbourne, but since it has been possible to assemble the types of all the fossil Chitons hitherto described from Australia, many of which were imperfectly figured, it has seemed desirable to enlarge the scope so that this paper may include all the known species.

Up to the present time sixteen species of fossil Chitons have been described from Australia, all from Victoria and Tasmania. Ashby and Torr described nine in 1901, Hall two in 1905, Hull one in 1910, and three by the same gentleman in 1915, and one by Ashby in 1921. Our knowledge of forms now living in Australian waters has advanced greatly since the earlier papers were written, therefore some revision of earlier work is made desirable.

Class Amphineura.

Order POLYPLACOPHORA, Blainville.

Sub-order EOPLACOPHORA, Pilsbry.

Polyplacophora with the tegmentum coextensive with the articulation, or with the latter projecting in smooth, unslit insertion plates; gills posterior.

Family LEPIDOPLEURIDAE, Pilsbry.

Genus *Lepidopleurus*, Risso.*LEPIDOPLEURUS MAGNOGRANIFER*, n. sp.

(Plate XVIII., Fig. 1.)

(Trans. Roy. Soc. S. Austr., vol. xxv., pt. ii., p. 142, 1901.)

Ashby and Torr in the paper (l.c.) gave a brief description of a single median valve under the No. 10, but gave it no name.

Having again carefully examined this valve and compared it with all the known forms living in Australian waters, as well as with many exotic ones, I am satisfied that one is fully justified in describing it and giving it a name. This is the first fossil member of the genus recorded from Australia.

One example of median valve, measuring 5 mm., laterally, and 2 mm., longitudinally.

Dorsal Area.—Is badly eroded, but in one spot there is evidence that this area was longitudinally ribbed.

Pleural Area.—Is decorated with somewhat bowed, longitudinal ribs, which start at the anterior margin of the lateral area, where they are crowded and narrow, but increase in width anteriorly; these ribs, although considerably worn, show pectination.

The evidence is sufficient to lead one to conclude that these longitudinal ribs when well preserved will be found to be composed of closely packed, imbricating, flattened granules, a feature that is so characteristic of the Australian members of this genus. I can count fourteen of these rows, but as before stated there is suggestive evidence that they were continued right over the dorsal area.

Lateral Area.—Differs entirely from any of our Australian forms in that its sculpture is very distinct from that of the rest of the valve. This area is strongly raised and decorated with four, increasing to seven at the girdle, radiating rows of very large, flat, irregular, although more circular than otherwise, granules.

Inside.—Insertion plates absent, sinus broad, sutural laminae small and shallow, tegmentum folded over at the posterior margin, the two lateral callus-portions are exceptionally high and broad.

Remarks.—In the absence of the end valves it is not possible to be certain under which of the genera of the Lepidopleuridae this species should be placed. I have compared it with representatives from my own collection, of the genera *Lepidopleurus*, *Hanleya*, *Oldroydia* and *Hemiarthrum*; it certainly more nearly corresponds with the first named, although the coarse sculpture of the lateral area approaches that of *Oldroydia*, but it does not possess the peculiar frontal extension of the jugal-tract, of that genus.

Locality.—Muddy Creek, Victoria; the particular bed not recorded. Type in Tate Museum, University of Adelaide.

Family PROTOCHITONIDAE, Ashby, n. fam.

Distinguished by the absence of insertion plates in the end valves; the presence of well defined sutural laminae and broad, although incomplete and unslit insertion plates in the median valves; strong granulose sculpture in all valves, the tail valve having a well defined mucro and great extension of the tegmentum posteriorly beyond the callus termination of the articulamentum. Type of Family *Protochiton granulosus*, Ashby and Torr (*Acanthochites granulosus*, Ashby and Torr, Trans. Roy. Soc. S. Austr., vol. xxv., pt. ii., pp. 139-140, pl. iv., fig. 9, 1901). Following Pilsbry in Zittel—his Sub-Order Eoplacophora will now have three families: (1) Gryphochitonidae, (2) Lepidopleuridae, (3) Protochitonidae.

Palaeozoic Chitons.—Pilsbry, in the English Translation of Zittel, by Eastman (vol. I., p. 434, 1900), gives the following classification, placing all the Palaeozoic forms under his new family Gryphochitonidae.

Genus	<i>Helminthochiton</i> , Salter	-	-	Silurian.
	<i>Priscochiton</i> , Billings	-	-	Ordovician.
	<i>Gryphochiton</i> , Gray	-	-	Carboniferous.
	<i>Pterochiton</i> , Cpr.	-	-	"
	<i>Cymatochiton</i> , Dall	-	-	Permian.
	<i>Probolaeum</i> , Cpr.	-	-	Devonian.
	<i>Chonechiton</i> , Cpr.	-	-	Carboniferous.
	<i>Loricites</i> , Cpr.	-	-	"

Pilsbry (Man. Conch., vol. xiv., p. xxiii, 1892), says: "It is commonly known that the earlier (Palaeozoic) Chitons are, without exception, destitute of insertion plates, and belong therefore to the family Lepidopleuridae."

Zittel (Hand. der Palaeontologie, Bd. II., p. 174, 1881-5), after referring to a number of Palaeozoic forms under the comprehensive term "Chiton," says "they are wanting in the Triassic, occur seldom in the Jurassic and Cretaceous, and appear also in the Tertiary deposits, but in few species."

Salter (Q.J.G.S., vol. iii., p. 48, 1847), refers to thirty-two fossil species. His figure of *Helminthochiton priscus* somewhat suggests the sculpture and shape of the frontal half of the shell described hereunder under the name *Protochiton granulosus*, but *priscus* possesses no insertion plate, and the posterior margin is V-shape, very different from *granulosus*.

Pilsbry, in Zittel (l.c. p. 433), says "none of the Palaeozoic genera are known to continue into the Mesozoic, but are replaced by types more related to modern chitons."

Protochiton, n. gen.

Chitons in which the insertion plates of the end valves are absent, the median valves having incomplete, unslit insertion plates.

The articulation is not weak, as in the *Lepidopleuridae*, but well developed; the valves after the first, are about equal in length and breadth, strongly sculptured with rows of elongate granules; the articulamentum of the tail valve ends in a callus portion beyond which the tegmentum is produced posteriorly for almost quarter of the total length of the tegmentum.

Type.—*Acanthochites granulosus*, Ashby and Torr. (l.c.).

Ashby and Torr in 1901 (l.c.) described this unique form from a median valve only; they pointed out that the insertion plate was unslit, nevertheless the form and sculpture of the valve determined them to place it under the genus *Acanthochites* [*Acanthochiton*].

Chapman (Proc. Roy. Soc. Vict., vol. xx. (n.s.), pt. ii., pp. 218-220, pl. xviii., Figs. 5, 6, 7, 1907), described and figured the tail valve under the name *Ischnochiton* (*Ischnoplax*) *granulosus*, Ashby and Torr sp., commenting thereon as follows: "This species must be transferred to the genus *Ischnochiton*, occasioned by the discovery of the tail-valve, particularly characterised by a callus-termination of the posterior border of the articulamentum; and to the subgenus *Ischnoplax*, since the shape of the valves indicates a narrow body, with an elevated posterior valve and a posteriorly situated mucro. In view of the fact that *Acanthochites*, subgenus *Notoplax*, is distinguished by the numerous slits in the articulamentum of the tail valve, which latter also projects beyond the tegmentum posteriorly, it is difficult to discern the ground upon which the original authors of this species founded their conclusions as to the genus in which it should be placed, seeing that they record only median valves." Chapman was misled by the subcrenulate callus-termination of the articulamentum of the tail valve, entirely overlooking the fact that the insertion plate was absent, whereas in the family *Ischnochitonidae* and the genus *Ischnoplax* it is present and slit. The only character that seems common to the two genera *Ischnoplax* and *Protochiton*, is that the valves indicate from their general shape that the animal had a narrow body, which feature is mentioned by Chapman.

Phylogenetic discussion.

The entire absence of insertion plates in the two end valves indicates its primitive origin, and the fact that all the genera of the *Lepidopleuridae*, other than the genus *Lepidopleurus* s.s., have insertion plates on one or both of the end valves, indicates that its progenitor, if derived through that Phylum at all, branched off at a very early stage of development of the simplest genus in that group. (The possibility of its being derived from earlier Palaeozoic or Mesozoic forms is referred to lower down in this discussion.) On the other hand, with the exception of the one character, i.e., the absence of the insertion in the end valves, it shows little affinity with any of the *Lepidopleuridae*. The shape of the valve, as long as broad, the well developed sutural laminae,

broad although incomplete insertion plates in the median valves, are certainly suggestive of the Acanthochitonidae, Hedley=Acanthochitidae, Pilsbry. Then we are faced with the fact that members of that family have highly developed slit insertion plates, in the end valves. I have therefore proposed for its reception the generic name *Protochiton*, and the family name *Protochitonidae*. To determine the exact niche in the Natural Taxis that this family should occupy is somewhat difficult.

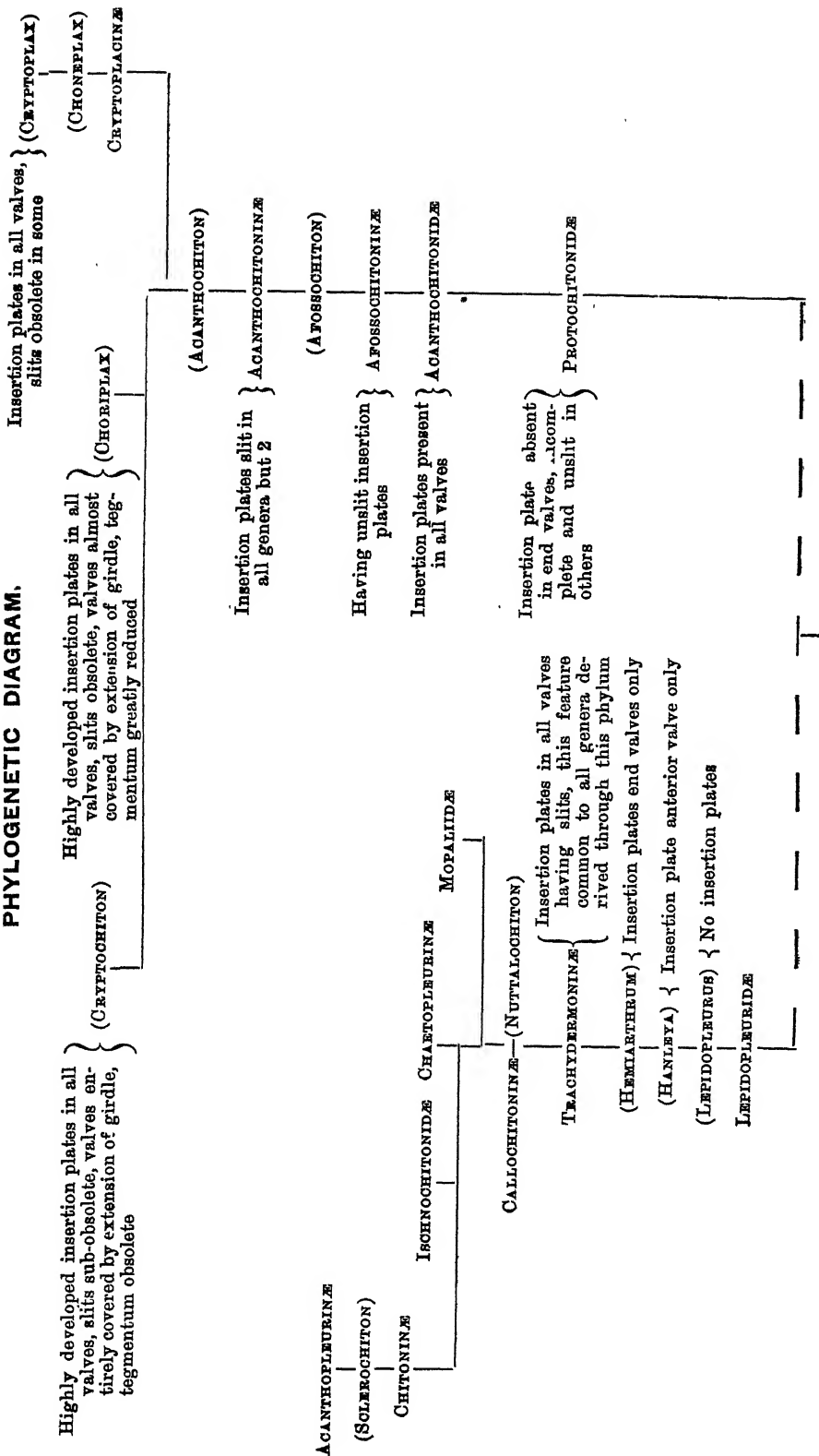
That there is a wide gap separating it from any of the living forms related to the genus *Acanthochiton*, all must admit, but I am confident that sooner or later some fossil form will be discovered intermediate between the two. But we are confronted with a gap no less wide between *Protochiton* and the genus *Lepidopleurus*. While I have suggested that the stock from which the Protochitonidae are derived, branched off just above the most primitive genus of the Lepidopleuridae, the features already pointed out, together with the extraordinary development of the tegmentum of the tail valve, evidence a specialization of no mean order. It appears to me that the girdle was attached by muscle fibres, not only to the callus-termination of the articulamentum, but also to the underside of the whole of the posterior extension of the tegmentum. If we are correct, and I certainly think we are, in assuming that the development of the insertion plates, and, later, their slitting and serration, has slowly been evolved for the purpose of giving stronger attachment for the girdle, and thereby making for the survival of the species; then we must conclude that the peculiar feature under discussion was a specialised development (or experiment, if you will) outwards, forming the posterior insertion plate, with a corresponding shrinkage of the upper shell or tegmentum, as in the genus *Acanthochiton*, this suppression of the upper shell reaching its maximum in the two genera *Chorioplax* and *Cryptochiton*.

Phylogenetic Diagram.

It is evident that the Phylum Acanthochitonidae branched off at a much more remote period than has previously been supposed. Thiele, in his Phylogenetic Diagram (Zool., Heft 56, pt. ii., p. 117), branches his Phylum Acanthochitidae immediately below the branch Mopaliidae, considering that both these families are derived from more primitive stock than the Chaetopleurinae, Ischnochitonidae, or Chitonidae. In my classification I derive the Phylum Acanthochitonidae from much more primitive stock still, branching it off from immediately above the genus *Lepidopleurus*, the most primitive genus of all living chitons.

I cannot but think that even this treatment falls short of the truth, and that it is really derived from Mesozoic or Palaeozoic forms, along parallel lines to those of the progenitors of the Lepidopleuridae. I show this in my Phylogenetic Diagram. If this can be determined, it introduces important modifications to our present classification.

PHYLOGENETIC DIAGRAM.



The earlier writers on Palaeozoic Chitons have largely ignored taxonomic features, often finding relationships on purely superficial likenesses. Neither the descriptions nor the figures furnish the evidence one seeks. Pilsbry, as before quoted, suggests that continuity is broken in the Mesozoic period, Chitons again recurring in the Tertiary.

The thought is forced upon one that it is possible that these missing links in the chain of sequence may have survived much longer in these Australian seas than has been the case in other parts of the world. I look forward for new discoveries to demonstrate that at least the *Acanthochitons* have been derived not through the *Lepidopleuridae*, but direct from Palaeozoic stock. The data available in various palaeontological works suggest that even in Palaeozoic times very diverse forms were already in existence, and considerable specialization in certain directions had already taken place. Most of them seem to have had narrow bodies, in this respect corresponding with the species under review, rather than with the members of the genus *Lepidopleurus*.

PROTOCHITON GRANULOSUS, (Ashby and Torr).

(Plate XVIII., Figs. 2, 3, 4, 5a,b.)

(*Acanthochites granulatus*, Ashby and Torr, Trans. Roy. Soc. S. Austr., vol. xxv., pt. ii., pp. 139-140, pl. iv., fig. 9, 1901; *Ischnochiton* (*Ischnoplax*) *granulosus*, of Chapman, Proc. Roy. Soc. Vict., vol. xx. (n.s.), pt. ii., pp. 218-220, pl. xviii., figs. 5, 6, 7, 1907.)

Type Description.—"Two examples of median valves.

"General Appearance.—Carinated beaked, side slope straight, except lateral area, which is reflex; color mottled in two shades of green, somewhat bleached.

"Dorsal Area.—This area is clearly defined, being broadly wedge shape, produced forward in a distinct beak, which is slightly bent downwards. A shallow depression separates this area from the pleural. Sculpture consists of about a score of longitudinal, closely packed granulose riblets. The granules increase in definition towards the margin of the pleural area, where they will be more correctly described as longitudinal rows of granules.

"Pleural Area.—In this area the rows of granules are radial, the rows being separated, widely apart, and very regular. In this area the granules become large, digitate, in some cases pointed, inclined very much forward, the apex of one just reaching to the base of the one in front of it. Where the apex is broken off the pustules are seen to be hollow.

"Lateral Area.—Raised or recurved, clearly defined, the pustules being rounded and granulose, becoming crowded and irregularly placed as they approach the posterior margin of valve.

"Inside.—The articulamentum was probably white. The insertion plates are well produced, though in the specimens under

examination rather broken, and apparently unslit. The upper surface of the sutural laminae is irregularly grooved, sinus broad.

"Measurement.—Width of valve, 7 mm.; length of valve, 7 mm.; length of slope, 5 mm.; divergence, 100°.

"Locality.—Schnapper Point."

There is but little to add to the foregoing description of the type median valve, except that the granulose ribs in the dorsal area are intercalated, almost doubling the number of rows named at the anterior margin.

The specimen before me from the same beds was collected by Mr. Francis Cudmore, and measures 9.5 mm. longitudinally and 11 mm. laterally. The production of the sutural laminae and incomplete insertion plate, is quite perfect, the former project in front of the tegmentum 2 mm., and the insertion plate is continued at full width to within $1\frac{1}{2}$ mm. of the posterior margin of the tegmentum, when it turns abruptly inwards, apparently at the exact point where the slit is developed in the genus *Acanthochiton*; from here the insertion is continued in a very shallow wedge-shaped extension almost to the posterior margin of the tegmentum. The eaves are well defined.

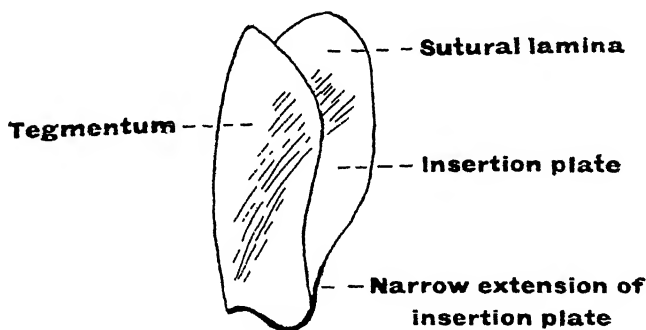


FIG 1.—Median valve of *Protochiton granulatus*, (Ashby and Torr).

Tail Valve.—The dorsal area is similar to that of the median valve, the mucro is post-median, deep and dropping abruptly to the flat posterior half of valve; the pleural area is similar in its decoration to the same area in the median valves, and is separated from the posterior portion of valve by a shallow, diagonal trough, produced forward; the posterior half of valve is flat to concave, the posterior third being recurved. Chapman (l.c.), in his description of this portion of the valve says, "Area behind mucro, plane, undulate or slightly concave, ornamented with numerous small pustules arranged in a rather obscurely quincuncial pattern. The outer borders of the pustules each carry a pigmented centre, slightly depressed, showing the presence of rudimentary eyes."

I would add that these granules are elongate, although more circular than is the case in the other areas. Under 65 mag. the central depressions referred to by Chapman, are seen to be longitudinal, with minute, irregularly placed micropores, in these depressions. While I have no doubt that these pores were the terminals to nerve fibres, I doubt whether they had in this shell been transformed into "eyes." Similar micropores are present, although less numerous in the median valves.

Inside.—White, smooth under dorsal area, from there deep grooves and ridges radiate outwards, half across the shell.

Anterior Valve.—Mr. Cudmore has been successful in collecting the anterior valve, which has not before been found, and is a valued addition to our knowledge of this interesting species. This valve measures longitudinally 4.5 mm., and laterally 7 mm., the anterior margin of the tegmentum reaches almost 0.5 mm. beyond the articulamentum, the valve is raised and decorated with about 60 radiating rows of packed, although separated, elliptical granules, which are very minute near the apex, and increase in size towards the margin. The rows in spite of being so crowded are well defined, except near the posterior margin; there the granules are a little confused and less elliptical. The inside is white, the articulamentum terminating anteriorly in a callus portion, the anterior third of the inside is much grooved, the tegmentum overlaps the posterior margin.

Localities.—Balcombe Bay; and one valve from Grice's Creek, Victoria (F. Cudmore coll.); also not uncommon at Clifton Bank, Muddy Creek.

Age.—Oligocene (Balcombian).

Sub-order CHITONINA, Thiele.

Family ACANTHOCHITONIDAE, Hedley.

Family Acanthochitonidae, Hedley¹, replaces Cryptoplacidae, Dall, and Acanthochitidae, Pilsbry; also the sub-family Acanthochitoninae, Ashby, replaces the sub-family Acanthochitinae, Thiele.

Thiele (Rev. des Syst. der Chit., p. 116, 1910) places the Acanthochitidae and Cryptoplacidae in one family, in which I concur. Iredale (Proc. Mal. Soc. Lond., vol. xi., pp. 34 and 126-7, 1914; Trans. N.Zd. Inst., vol. 47, p. 422, 1915), also concurs with Thiele in this, but substitutes the new family name Cryptoconchidae, founding it on the genus *Cryptoconchus*, which dates from Burrow's note of 1815 and, therefore, antedates *Acanthochiton*, Gray, 1821. I myself accepted Iredale's dictum both in a published paper and in MSS., expressing regret that owing to the law of priority the name of the typical genus *Acanthochiton* should be lost as a

¹ Hedley in Index Moll. of West Austr.; Jour. Roy. Soc. West Austr., vol. i., p. 24, 1916, uses "Family Acanthochitonidae"; also W. H. Dall in List U.S. Nat. Mus. Bull. 112, p. 197, 1921, uses the same family name.

family name. Several of my friends have kindly pointed out to me that that law does not apply to ordinal or family names, the word "type-genus" in Article 4 (International Rules) meaning "typical genus."

The genus *Acanthochitona*, Gray, in "London Medical Repository," vol. xv., p. 234, 1821, antedates *Acanthochites*, Risso, 1826. Iredale, l.c., p. 422, emended the terminal *a* thus, *Acanthochiton*, Gray, 1821, em. Odhner and myself have followed him in this, for there are a good many precedents, and under Article 19 (Int. Rul.), "an error of transcription" may be amended. At this late date it will be impossible to prove that this unfortunate terminal *a* was due to such an error, but it will be equally impossible to prove to the contrary. My friend, S. S. Berry, of California, expressed the feelings of all, I think, when he wrote me, "I would be as pleased to get rid of that final *a* as yourself."

I consider the rule quoted supplies a loop-hole and the common-sense course is to take it. A decision approving this might well be adopted at the next International Congress. Article 5 states that the name of a family or sub-family is to be changed when the type genus is changed. As the names Acanthochitidae, Pilsbry and Acanthochitinae, Thiele are both founded on *Acanthochites*, Risso the adoption of the earlier generic name *Acanthochitona*, or as emended, *Acanthochiton*, Gray gives us the family Acanthochitonidae, and sub-family Acanthochitoninae. As these are not amendments, but new names, one is regretfully unable to attach the names of Pilsbry and Thiele as authors.

Sub-family AFOSSOCHITONINAE, Ashby, n. sub-fam.

(Unslit insertion plates).

Afossochiton, n. gen.

Having median valves similar in sculpture and general shape to members of the genus *Acanthochiton*, but in which the insertion plate is narrower, and having neither slit nor suture present, the slit in the Acanthochitons is usually short, but is continued to the tegmentum in a deep channel or suture. Both slit and suture are absent in members of this genus, whereas they are both present in members of the subfamily Acanthochitoninae; on this account this genus must precede that subfamily, being a closely related but more primitive form. I cite *Afossochiton cudmorei*, Ashby, as type of this new genus.

AFOSSOCHITON CUDMOREI, n. sp.

(Plate XVIII., Figs. 6, 7.)

Among the specimens sent me for examination by Mr. Francis Cudmore are two median valves of a new species, which I at first intended to include under the genus *Acanthochiton*. In the

collection in the Tate Museum, University of Adelaide, is another similar valve, though not as well preserved, collected at the same locality more than twenty-five years ago, I have pleasure in naming this species after Mr. Cudmore, to whose energetic collecting we are indebted for the opportunity of determining the characters of these fossil chitons.

Specimen No. 1, Holotype.—This is the smaller of the two specimens, which are both median valves, but this one is in the best state of preservation; it measures 4 mm. longitudinally and 6 mm. laterally. Shell carinated, jugum is worn and in present condition rounded, side slope is straight from the margin of dorsal area to the outer edge of shell; the dorsal area is wedge-shaped, beaked and regularly pinnatifid, the toothed margin of this area consists of five well defined teeth on either side, the central portion of this area is too eroded to determine the sculpture.

Lateral Area.—Is narrow and raised, separated from the pleural area by a diagonal, rather abrupt fold. Both the pleural and lateral areas are decorated with nine or ten rows of wedge-shaped, raised granules, each granule is a perfect isosceles triangle, with the base upwards and the apex outwards. The rows of granules commence at the posterior margin, are a little confused in the lateral area, but are very regular in the pleural area. The rows run on the diagonal, and the granules are placed diagonally in the rows. The rows commencing near the beak have very small granules to start with, which rapidly increase in size towards the outer margin, the granules in the lateral area in addition to being in less well defined rows, are larger, and also increase in size towards the insertion plate.

Inside.—The sutural laminae have been broken off, the insertion plates are fairly broad, but not so much so, as in the genus *Acanthochiton* the margin is damaged and unsplit, the tegmentum is infolded under the beak for a short distance (laterally), there are two strongly raised callus portions diverging from the apex, forming a deep V-shaped hollow between them.

Holotype in Nat. Mus. Coll. [13311], pres. F. A. Cudmore.

Specimen No. 2, Paratype.—This also is a median valve, and measures 4 mm. longitudinally, and 7 mm. laterally. The valve is similar in shape to the type, except that there is a well defined trough, commencing below the beak and running parallel with the margin of the dorsal area; from this trough the side slope is less steep than the type, the sculpture is similar where not eroded. One insertion plate is complete, unsplit and without the transverse sinus that accompanies the slit in the genus *Acanthochiton*. The sutural laminae are missing.

Specimen No. 3, Paratype.—This also is a medium valve, measuring longitudinally 5.5 mm., and laterally 9 mm., while the valve surface is less well preserved than the other two, the insertion plates are both fairly complete, and the sutural laminae are present, and produced forward, the sinus between being wide. The peculiar wedge-shape sculpture is present only in a limited

degree. The specimen is the *Acanthochiton*, No. 18, mentioned in Ashby and Torr's paper of 1901 (l.c.). It was then considered too poor a specimen to describe and name.

Locality.—Clifton Bank, Muddy Creek, near Hamilton, Victoria.

Age.—Oligocene (Balcombian).

AFOSSOCHITON ROSTRATUS, (Ashby and Torr).

(Plate XVIII., Fig. 8.)

(*Acanthochites rostratus*, Ashby and Torr, Trans. Roy. Soc. S. Austr., vol. xxv., pt. ii., p. 140, pl. iv., fig. 5, 1901.)

Type description.—"One median valve.

"General Appearance.—Carinated, side slope straight, strongly beaked. Color porcelain white.

"Dorsal Area.—Wedge shape, much raised, convex, strongly beaked, the beak bent downwards. This area is smooth and glossy under an ordinary pocket lens, but under a fairly high power it is seen to be pitted with irregular shallow pitting, highly polished.

"Lateral and Pleural Areas.—These areas are hardly separable. The shell is a little thickened, and the sculpture a little coarser in the lateral area. The ornamentation consists of a number of somewhat irregular longitudinal rows of finger-shaped flattened pustules. The pustules are set diagonally in the rows, and increase to double the size as they reach the margin of the shell. The posterior margin of valve is bent downwards.

"Measurement.—Longitudinally, 3 mm.; breadth, 5 mm.; divergence, 105°.

"Inside.—White, insertion plates and sutural laminae not large, sinus broad and shallow, only indicated by a slight sinuosity of outline.

"Locality.—Schnapper Point."

The only addition needed is, that the tegmentum is folded over under the beak with a peculiar twist in the fold, and the fact that the insertion plates are unsplit, and the sinus which accompanies the slit, is absent as well.

Locality.—Balcombe Bay, Victoria.

Age.—Oligocene (Balcombian).

Note.—While at first I intended placing the foregoing two species under the sub-family Cryptoconchinae, close to the genus *Acanthochiton*, one soon realised that unless one assumed that they were representatives of a more specialized genus, in which the slits had become obsolete—a view that seems quite unsupported by any evidence to be obtained from the three median valves—then they are most certainly a primitive type allied to the above-named sub-family. As this assumption is entirely based on the evidence of the median valves alone, their true position in

the Natural Taxis cannot be determined until the end valves are discovered, for although I do not expect it, these valves may be without insertion plates, in which case they will need to be placed under the Protochitonidae. My own opinion is that the species when the full data is available will be found to be nearer the family under which I have provisionally placed them, than to the still more primitive Protochitonidae.

Sub-family ACANTHOCHITONINAE, Ashby.

Genus *Acanthochiton*, Gray, em.

ACANTHOCHITON CHAPMANI, n. sp.

(Plate XVIII., Fig. 9.)

A considerably damaged median valve, of what is apparently a member of the genus *Acanthochiton*, was collected by Mr. Frederick Chapman, at Clifton Bank. In addition to being a good deal worn and the posterior margin weathered, the insertion plates and sutural laminae are either absent or too broken to describe. Still the characters that remain seem sufficiently distinctive to warrant one in giving it a name, and I have much pleasure in calling it after the discoverer.

Description.—Median valve, incomplete, measuring 6 mm. longitudinally, and 7 mm. laterally; carinated, elevated and strongly beaked, posterior margin of valve slants rapidly forward from the beak, the decoration is composed of large, squamose granules, but the most striking feature is an exceptionally raised and coarse diagonal rib; the dorsal area is well defined and arched longitudinally.

Holotype in Nat. Mus. Coll. [13312], pres. F. Chapman.

Locality.—Clifton Bank, Muddy Creek, Victoria.

Age.—Oligocene (Balcombian).

Note.—In the absence of the end valves, and very imperfect sutural laminae and insertion plates, I have provisionally placed it under the above genus, trusting that at no distant date better specimens will be discovered when more accurate determination of its features will be possible.

Sub-family CRYPTOPLACINAE, Thiele.

Genus *Cryptoplax*, Blainville.

In 1905 some interesting fossil valves were described by T. S. Hall, under the names *Cryptoplax pritchardi* and *gatliffi*. Through the kindness of Messrs. Chapman and Cudmore I have been able to examine all the specimens collected by themselves, and also those collected by the late T. S. Hall—in all fully 50 specimens.

They range in length from 3.5 mm. to 11 mm.; all, with one exception, if really *Cryptoplax* valves, are median valves. The one exception is deeply and closely grooved on the inside, the

fluting between the grooves ends in perforations, which suggests that when perfect it was serrate or comb-like at the edge—certainly not a *Cryptoplax* valve. There is not the least suggestion in any of the 50 valves, of the existence of the tegmentum or upper, sculptured layer of shell. In addition to all the species of *Cryptoplax* recorded, as found in Australia, I have examined those from Japan, the Pacific Islands and Madagascar. In every case, however eroded the specimen, the tegmentum exists at the outer margin of the valves and where protected by the girdle. *C. larvaeformis*, (Blainv.) Burrow, from Tonga, does show valves with a polished surface on those portions of the shell from which the tegmentum has been eroded, but some part of the tegmentum is present at the sides of all valves.

Mere frictional erosion will not account for the condition of these 50 fossil valves. As far as I can see the only hypothesis that could account for the entire absence of the tegmentum is that some chemical action has taken place which was able to destroy the upper layer only, leaving the articulamentum intact. Or are they representatives of some extinct genus in which the tegmentum had become obsolete as in the genus *Cryptochiton*?

I have disarticulated living Echini, but their teeth and teeth sheath (alveolus) do not correspond, neither do parts of Sessile Barnacles (Cirripedia) furnish any solution; also the possibility of some member of the Fissurellidae throwing light on the subject has suggested itself. All this evidence is negative; we may hope that the collecting of new material will furnish evidence of a more positive nature.

CRYPTOPLAX PRITCHARDI, Hall.

(Plate XVIII., Figs. 11, 12; Pl. XIX., Figs. 13, 14, 15, 16.)

(Proc. Roy. Soc. Vict., n.s., vol. xvii., pt. ii., pp. 391-2, pl. xxx, figs. 1-6, 1905.)

Type Description.—"All the specimens of the valves that I have found—thirty in number—are much worn, and are polished by attrition, like so many of the fossils in the Kalimnan of Muddy Creek, and in very few cases is the articulamentum [read tegmentum] distinctly shown. The valves approach those of *C. gunni* very closely in shape; indeed, were shape all that we had to guide us, there would be little justification in separating the fossil from it. In a few cases, however, traces of the sculpture of the tegmentum are preserved, and this enables differences of specific value to be pointed out. In *C. gunni* the coarse grooving radiates from the apex, whereas in the present species faint traces of coarse concentric sculpture are visible. In this point *C. pritchardi* makes an approach to *C. larvaeformis*, as figured by Pilsbry. Valve VIII. (see Figs. 3 and 4), allowing for its worn condition, is almost identical in shape with that of *C. gunni*, the posterior insertion plate being vertical.

Median length of specimen shown in Figs. 1 and 2, 7.5 mm.; breadth, 2.5 mm. Median length of original of Figs. 3 and 4, 6.6 mm.; breadth, 2.5 mm.; depth, 1.6. mm. Length of original of Figs. 5 and 6, 4 mm.; breadth, 4 mm.

Locality.—McDonald's, Muddy Creek. Kalimnan (?Miocene²). Thirty examples."

CRYPTOPLAX GATLIFFI, Hall.

(Plate XVIII., Figs. 10*a, b*).

(*l.c.* pp. 392-3, pl. xxx., figs. 7-9.)

Type Description.—"Only a single valve has as yet come under my observation, and this is imperfect anteriorly. The articulation is shown on both sides. In shape it differs from any of the valves of *C. pritchardi*, being less pointed posteriorly. The posterior end is produced downwards into a slight hook-like process, which is shown in side view in Fig. 8. Viewed from below this process is crescentic, as it follows the curve of the valve, and its lower surface is flat. This feature, though absent from the recent species and from *C. pritchardi*, occurs in some of the other genera of Polyplacophora.

"The tegmentum is smooth, being abraded, but traces of a median ridge are traceable, the shell in this region being irregularly and finely pitted. Median length of valve (imperfect), 3.7 mm.; breadth, 1.9 mm.

"Locality.—Clifton Bank, Muddy Creek. Balcombian (?Eocene³). A single valve."

I have transcribed above Hall's original descriptions of his two species. Since writing my foreword I have again gone carefully through the whole of the material, and I find that while none of the examples seem true end valves of a *Cryptoplax*, there is certainly a very wide divergence in shape. Some are blunt ended and thick, others are pointed and fragile; under the apex of most is a narrow central ridge, some are bent down at the apex and one shows the thickened process under the apex, which led Hall to describe his second species, *C. gatliffi*, in other respects the two forms seem identical. If the impression I have had ever since I first saw these strange, so-called valves, that they are not portions of the coat of mail of a *Chiton*, is correct, then I think it not unlikely that this little process under the apex may be the clue to the solution. The valves vary also from narrow and straight-sided to broadly wedge-shaped, and in some cases spatulate; a few show compression or incurving laterally.

The concentric ridges which are described by Hall as being visible in some examples, hardly I think correspond with the

2. Regarded in the present paper as Lower Pliocene.

3. Here regarded as Oligocene.

sculpture that is common to members of the genus *Cryptoplax*. The ridges in the specimens under review, start from the base of the smooth dorsal area, and are bowed towards the apex. While I cannot feel satisfied that these interesting little objects are *Cryptoplax* valves, I must admit that up till the present one has absolutely failed to demonstrate that they are something else. May not the polished surface which is so marked in the most perfect specimens be the result of some enveloping mantle, and not due to attrition, as suggested by Hall?

Addenda.—Since writing the foregoing, Hall's original types have been sent to me, and photographs appear in the plate attached to this paper. Two additional features are exhibited in these specimens; one of the cotypes of *C. pritchardi* has no apex, but what in other examples is the apical end is in that turned over like the inside of the heel end of a slipper (is figured sideways in plate). Then the holotype of *C. gatliffi* differs in one respect only, from the majority of the specimens described as *C. pritchardi*, in that it possesses a lobe-shape plate on the inside, just under the apex. This plate will probably furnish a clue to the true character of these structures.

This plate suggests either a bearing or grinding plate, and may possibly have originally been present in the valves of *pritchardi* as well. I admit that the existence of these two features confirms me in the belief in their non-chitonoid origin. The plate evidently filled some purpose that would be inapplicable to the valves of a Chiton.

Family MOPALIIDAE, Pilsbry.

Genus *Plaxiphora*, Gray.

PLAXIPHORA CONCENTRICA, Ashby and Torr.

(Plate XIX., Fig. 18.)

(*l.c.* pp. 138-9, pl. iv., fig. 8.)

Type Description.—"One example of posterior valve only.

"General Appearance.—Broad, rounded. Color pale-brown, slightly olivaceous. The tegmentum is posteriorly bent over, and continued for some distance on the underside of shell. Mucro evidently postmedian, though much worn. The anterior portion of shell well preserved, showing six strong concentric ribs, each following closely the contour of the margin of the shell. There are evidences that these ribs were continued without any break right round the posterior margin, though the ribbing in this part of shell is less strong, and the ribs are closer together. No other sculpture is discernible on the tegmentum. Insertion plates unslit in the posterior valve.

"Measurement.—Posterior valve, total width 17 mm., total length, 10 mm.; width of tegmentum only, 15 mm.; length of tegmentum only, 7 mm.

" Inside.—Articulamentum white, sinus 4 mm. wide at apex, 8 mm. at widest part. Sutural laminae produced beyond the tegmentum, $4\frac{1}{2}$ mm. The sutural laminae and insertion plates are remarkably posteriorly thickened. The two dorsal pits and lateral grooves are very deep.

" Remarks.—This shell is allied to the living forms *Plaxiphora petholata*, Sby., and *P. glauca*, Q. and G., rather more so to the latter than to the former. It is more strongly concentrically ribbed, more evenly rounded, sinus narrower, sutural laminae twice the length, the anterior margin of tegmentum slightly produced forward in the centre of the sinus, and the inside is white instead of greenish-blue. The microscopic vermiculate wrinkling is quite absent in the specimen under description."

Locality.—Gellibrand, Victoria.

Age.—Probably Miocene (Janjukian).

PLAXIPHORA GELLIBRANDI, Ashby and Torr.

(*l.c.* p. 139, pl. iv., fig. 1.)

· *Type Description*.—" One example of posterior valve.

· " General Appearance.—Broad, flat, jugum slightly raised, side slope nearly straight. Color blackish, with irregular streaks of green. A pale broad wedge-shaped mark on dorsal ridge.

· " Mucro.—Post median, slightly raised.

· " Dorsal Area.—Slightly raised and ornamented with a broad whitish wedge-shape mark. A shallow curved diagonal rib runs from the mucro forward, keeping near the margin of valve. The whole of the valve is ornamented with the same peculiar sculpture that is present in *Plaxiphora petholata*, Sby., and which Sowerby in his description describes as a microscopic pattern resembling a dense punctulation, united with a minute zig-zag or vermiculate wrinkling.

· " Measurement.—Posterior valve, total width, 14 mm.; total length, 8 mm.; width of tegmentum only, 11 mm.; length of tegmentum only, 5 mm.

· " Inside.—Articulamentum white, sinus 3 mm. at apex, increasing to 6 mm.; sutural laminae produced beyond tegmentum 3 mm. The eves [*sic*] are shallow and spongy. The articulamentum of insertion plates and sutural laminae is greatly thickened. The two dorsal pits and corresponding lateral grooves are very deep.

· " Locality.—Eocene⁴ beds, Gellibrand, Victoria.

· " Remarks.—This species very closely resembles *P. petholata*, Sby. The inside pits and lateral grooves are deeper, and the inside color white instead of greenish blue. The shell is also broader, and the anterior margin of tegmentum is slightly produced forward."

4. Probably Miocene (Janjukian).

Note.—The foregoing two members of the genus *Plaxiphora* are so close to the very variable living form that I think at most they can only rank as sub-species. When more material is available something more definite may be determined; *gellibrandi* certainly looks like a recent shell, and may have slipped into the collection by mistake. In the remarks read *P. alba*, Blainville, for *petholata*, and *P. tasmanica*, Thiele, for *glauca*. In faint writing on box containing type of *P. concentrica* are the words, "I have put in a specimen for compare." I should prefer to retain only the name *P. concentrica* for fossil species; believing that the valve described under the name *gellibrandi* is the valve that had been put into the box containing *concentrica* for comparison. I have followed Thiele (*Zoologica*, p. 117, l.c.) in placing the family Mopaliidae earlier than the family Ischnochitonidae.

Family ISCHNOCHITONIDAE, Pilsbry.

Sub-family CALLISTOPLACINAE, Pilsbry.

Genus *Callistochiton*, Carpenter.

CALLISTOCHITON MERIDIONALIS, Ashby.

(Plate XIX., Fig. 19.)

(Trans. Roy. Soc. S. Austr., vol. xliii., p. 400, 1919.)

The credit is due to Mr. Chapman for having collected the first recorded fossil *Callistochiton* in Australia. He collected one median valve only at Forsyth's, Grange Burn, and a portion of a median valve at MacDonald's, Muddy Creek (upper beds). It is rather worn, the sutural laminae are missing, and the central part of the anterior margin of valve has broken away, but the sculpture is sufficiently preserved to enable one to form the opinion that it is conspecific with the living form described under the above name. The longitudinal ribs agree more closely with *meridionalis*, Ashby, than with *antiquus*, Rve.

Holotype in Nat. Mus. Coll. [13319], pres. F. Chapman.

Locality.—Forsyth's, Grange Burn, and MacDonald's, Muddy Creek, Victoria.

Age.—Lower Pliocene (Kalinman).

Family CHITONIDAE, Pilsbry.

Sub-family CHITONINAE, Pilsbry.

Genus *Chiton*, Linne.

Sub-genus *Rhyssoplax*, Thiele.

The genus *Rhyssoplax* was founded by Thiele on the characters of the radula of *Chiton affinis*, Issel, from the Gulf of Suez. The specimen examined by Thiele was wrongly labelled *Chiton janeir-*

ensis, Gray. Thiele in his later work dropped the name *Rhyssoplax* in favour of *Clathropleura*, Tiberi; the specimen Thiele examined under this generic name was labelled *C. sicula*, Gray, whereas its correct name was *Chiton olivaceus*, Spengler, a common Mediterranean species. Pilsbry, in his Monograph, vol. xv., p. 67, 1893, shows that the specimen upon which the genus *Clathropleura* was founded by Tiberi, was a *Callochiton*. Iredale in Proc. Mal. Soc., vol. xi., p. 40, 1914, discusses this position, and says, "I here designate *Ch. laevis* (Pennant) Tiberi, as type of *Clathropleura*." Iredale evidently had quite overlooked the fact that Pilsbry had pointed out this position as long ago as 1893. Iredale in the same discussion proposes to include the Australian and New Zealand Chitons under Thiele's subgenus *Rhyssoplax* which was founded upon a European species.

We have this position: Thiele in Gebiss der Schnecken, pp. 267-8, 1893, proposed two generic names for two closely allied species; in his Revision des Systems der Chitonen, pt. ii., p. 117, 1910, he drops *Rhyssoplax* in favour of *Clathropleura*, giving it sub-generic value only; Pilsbry had already shown that Tiberi's name was not available, and Iredale, as before quoted, revives Thiele's name *Rhyssoplax* to replace the name used by Thiele, for a sub-genus of the genus *Chiton*, and proposed that it should be given full generic rank, but neither he nor any workers that have followed him, including the writer, have, as far as I am aware, published any results of an examination of the internal parts of this group of Australasian Chitons, and nothing has been advanced in support of the elevation of *Rhyssoplax* into full generic rank. I consider that it should, until more thorough work is done, be considered a sub-genus of the genus *Chiton*. Although superficially the southern forms from Australia seem congeneric with the northern European ones referred to, a more thorough study may not unlikely yet lead to their separation.

CHITON (RHYSSOPLAX) FOSSICIUS, Ashby and Torr.

(Plate XIX., Fig. 21.)

(Trans. Roy Soc. S. Austr., vol. xxv., pt. ii., pp. 140-1, pl. 4, Fig. 4, 1901.)

Type Description.—"One example median valve.

"General Appearance.—Valve narrow, carinated, side slopes nearly straight. Color pale olivaceous buff.

"Lateral Area.—This area is separated from the pleural area by a much raised, broad, diagonal rib. This rib occupies fully one-half of the area; on the other half are two shallow radial ribs.

"Pleural Area.—This area appears to have been sculptured right up to the dorsal ridge, with about 13 sharply chiselled, imbricating longitudinal ribs. The sutures between the ribs are deeply cut, and end as they reach the raised diagonal rib of the lateral

area in a very deep pit. So deep are these pits that with the naked eye they appear to be perforations through the tegmentum.

"Dorsal Area.—This area is much worn, but, as before stated, there are indications that the ribbing of the pleural area was continued right over this area. The valve is slightly beaked, which is smooth, no striae being discernible.

"Measurement.—Greatest width between the slopes, 10 mm.; greatest width of slope, 4 mm.; length of slope, 7 mm.; divergence, 95°.

"Remarks.—Under a strong lens the whole valve, except the beak, is found to be decussated or ornamented with a network of perforations, this being due to the exceptional development of the megalopores. The sutural laminae are much broken away, but the sinus was probably fairly broad and shallow. The insertion plates are quite missing—they have probably broken away. The most striking feature of this shell is the diagonal row of deep pits in the pleural area, and the much elevated broad diagonal rib of the lateral area.

"Locality.—Table Cape." [Tasmania.]

Age.—Miocene (Janjukian).

Note.—Thiele (Zoologica Revis. des Sys. der Chitonon, pt. ii., pp. 116-7) discards Pilsbry's two Sub-families, Callistoplacinae and Liolophurinae; he removes the two genera *Lorica* and *Loricella* from the Family Chitonidae, and places them next to the genus *Callistochiton*, under the Family Ischnochitonidae. He bases his views on the characters of the radula. I do not feel justified in following him in this, for the structure of the insertion plates, the peculiar tail valve and girdle characters of both these genera are extremely diverse from other members of the Ischnochitonidae. Until one has an opportunity of exhaustively studying the living animals, I prefer to follow Pilsbry in the retention of the two Sub-families Callistoplacinae and Liolophurinae.

Sub-family LIOLOPHURINAE, Pilsbry.

Genus .*Lorica*, H. and A. Adams.

This genus, as stated above, was placed by Pilsbry under the Liolophurinae when he published his Monograph, 1892-3, when only a single species was recognised, *L. volvox*, Reeve, but since then *L. cimolea*, Reeve, has been recognised, and *L. haurakiensis*, Mestayer, from New Zealand, described. Three fossil forms have been described: *L. compressa* and *L. affinis* by Ashby and Torr, in 1901, and *L. duniana* by Hull, in 1910.

A careful examination of the living forms reveals the fact that the median valves in members of this genus show a great variation in both shape and sculpture in the same specimen, and a wide divergence in the adult from the juvenile form. It is, therefore, very difficult to determine whether individual valves show-

ing wide differences are deserving of specific rank, or are mere variations, sometimes in the same individual. Thus the shape and sculpture of valve 2 is always very different from that of the other median valves.

LORICA COMPRESSA, Ashby and Torr.

(Plate XIX., Figs. 22, 23, 24.)

(Trans. Roy. Soc. S. Austr., vol. xxv., pt. ii., pp. 136-7, pl. iv., fig. 6.)

Type Description.—"One example of median valve.

"General Appearance.—Strongly carinated, side slope straight, color yellowish to dark-brown. The valves are produced forward in an anterior beak.

"Lateral Area.—Much raised, ornamented with five, increasing to eight, at the insertion plates, granulose ridges. The granules near the girdle are arranged in transverse rows.

"Pleural Area.—This area is longitudinally ribbed with sixteen strong ridges, the interspaces are deep, the anterior portion is about the same width as the ridges, the posterior portion about double the width. There is a suggestion that the ridges were crossed by shallow transverse ridging.

"Dorsal Area.—This area is not separated from the pleural, the longitudinal ridging being continued right over the jugum.

"Measurement.—Greatest width between the slopes, 24 mm.; greatest width of slopes, 11 mm.; greatest length of slope, 18 mm. The longitudinal measurement of the dorsal area is 12 mm.; divergence, 85°. The insertion plates and sutural laminae are missing.

"Remarks.—This species differs from *Lorica volvox* and *L. affinis* in the strong radial ribbing of the lateral areas and the great number of the longitudinal ribs in the pleural area, but it corresponds with *L. affinis* in the compression of the side slopes. The decussation of the interspaces present in *L. affinis* is absent in this species."

Comments by Writer.—The depth of the interspaces between the longitudinal ribs in the median area is evidently due to erosion and the same factor accounts for the apparent great width of the ribs themselves, also in the lateral area the granules are almost worn down to the shallow radial ribs which they surmount.

Tail Valve.—This valve is laterally much less spread than is the case in the living form *cimolea*, the extremity of the tail is more elevated, the posterior margin more thickened, and whereas the granules on this valve are absent or subobsolete in the living form, in this species they are well defined, although limited to two or three rows corresponding to the lateral areas of the median valves.

This is the first record of the tail valve of this species, and was collected by Mr. Francis Cudmore, and by him deposited in the collection of the National Museum, Melbourne. Several median valves were also obtained, showing some variation, but all having extensive infolding of the tegmentum, below the beak, on the inside of the shell. It is now possible to figure the sutural laminae which were absent in the type.

Plesiotype in Nat. Mus. [13320], pres. F. A. Cudmore.

Locality.—Table Cape, Tasmania.

Age.—Miocene (Janjukian).

LORICA COMPRESSA, var. AFFINIS, (Ashby and Torr).

(Plate XX., Figs. 25, 26.)

(*Lorica affinis*, Ashby and Torr, l.c. p. 137, pl. iv., fig. 7, 1901; *Lorica duniana*, Hull, Proc. Linn. Soc. N.S.W., vol. xxxv., pt. 3, p. 654, 1910).

Type Description.—"One example of median valve.

"General Appearance.—Carinated, side slope slightly curved, though almost straight, color pale yellowish-brown.

"Lateral Area.—Distinctly raised, ornamented with six radial rows of somewhat distant pustules which rise out of very shallow ridges.

"Pleural Area.—Longitudinally ribbed with twelve narrow, but strong ridges; the interspaces are fully three times the width of the ribs, and nearly flat; these ridges have a slight tendency to granulation, but the transverse striae which produce the same appearance in its congener, *Lorica volvox*, are not discernible in this species. The megalopores are very pronounced, giving under a powerful lens a strongly decussated appearance.

"Measurement.—The greatest width between the slopes is 20 mm.; width of slopes, 10 mm.; length of slopes, 15 mm.; divergence, 90°.

"Insertion plates have broken away; there is no indication of teeth."

Hull, in his description of *L. duniana*, makes the following comments:—"This species is allied to *L. affinis*, Ashby and Torr, but is distinguishable from that species by the wider interpaces in the central area, and the larger pustules, and number of rows on the lateral areas."

I have no hesitation in considering *L. duniana*, Hull, identical with this form. The type (Pl. XX., Fig. 25) was an incomplete valve. This, together with the poor figure, no doubt accounts for Hull considering them distinct. If the missing portions of the sculpture of the median areas were restored, the number of longitudinal ribs would be the same as in Hull's figure of *duniana*. Similarly, if the missing posterior row of granules in the lateral area be restored, the radiating rows of granules would at the

outer margin also correspond. In this variety the dorsal ridge is straighter and the radial undulations in the lateral areas are less in evidence than is the case in *compressa* s.s., but the chief difference is in the greater width of the interspaces between the longitudinal ribs. The proportional spacing of the different species is much as follows:—

L. cimolea and *L. compressa* var. *affinis*, equally wide spacing.

L. compressa, sensu stricto, narrow spacing, about 25% more ribs.

L. volvox, much narrower, nearly double as many ribs as *cimolea*.

All, in some specimens, give some evidence of pectination, but *volvox* much more so; in some examples of *volvox* complete bridging is developed.

Locality.—Table Cape, Tasmania.

Age.—Miocene (Janjukian).

LORICA CUDMOREI, n. sp.

(Plate XX., Figs. 27a-c, 28.)

In the collection of the National Museum, Melbourne, and in his private collection, are altogether nine more or less perfect median valves collected by Mr. Francis A. Cudmore, which are consistently distinct from any described species; also among the specimens loaned to me by the widow of the late E. D. Atkinson are two similar valves. I have pleasure in naming this species after Mr. Cudmore.

Median Valves.—All the median valves examined are much arched longitudinally from the beak forward, in this respect being very different from either *cimolea* or *compressa*, except in valve 2, which in *cimolea* is arched, though to a much less degree; it is not likely that all the valves under consideration are each the second valve, so we may conclude that in the living shell valves 2 to 7 are all very much arched longitudinally. All the valves are strongly carinated, the angle of divergence being considerably less than *cimolea*. The sinus between the sutural laminae appears wide in several specimens, and in the one I have chosen as type, but this appearance may be due to breaking away; of this I cannot be certain. Insertion plates present, slits 1/1, insertion propped and deeply grooved on the upper side. The longitudinal sculpture of the dorsal area consists of rapidly diverging ribs. I count ten at the anterior margin, thus making the area broadly wedge shaped. The longitudinal ribs in the pleural area are in the upper two-thirds of valve bent down anteriorly, almost running into one another, and thereby making room for the broad dorsal area. This feature is more marked than in any other form. All valves are much compressed laterally. The ribs nearest to the dorsal area are pectinated, becoming less so in the outer ribs, which are also more widely spaced. The lateral area is strongly raised and decorated

with five complete radial rows, of widely-spaced, finger-like grains. These rows are intercalated, making the total number of rows, including the outer ones, ten. The infold of the tegmentum under the beak is much narrower than in *L. compressa*. The median valve has a well defined row of closely packed cavities or large pores (I counted over 30 holes which were probably the terminals of the megal aesthetes, and may or may not have been transformed into "eyes"). In the living forms of members of this genus, these apertures are usually obsolete or sub-obsolete; this row of pores is situated on the unsculptured slope which divides the lateral area from the pleural. In the upper half of the shell the longitudinal ribs have on the lower side a number of similar pores, which contribute to the pectinated appearance.

Measurements.—11.5 mm. longitudinally, by 18 mm. laterally.

Holotype in National Museum, Melbourne [13321], pres. F. A. Cudmore.

Locality.—Table Cape beds, Tasmania.

Age.—Miocene (Janjukian).

Anterior Valve.—I am associating with the above an anterior valve which was also collected by Mr. Cudmore at the same locality. Strongly elevated, laterally compressed, apex recurved, making the anterior slope concave, decorated with 29 radial rows of spaced, raised, circular grains. The posterior margin is edged with a row of coarse grains that give it a toothed appearance, the tegmentum is folded over to the inside throughout the whole length of the posterior margin and under the apex is broadly so, and there coarsely, longitudinally ribbed.

Nat. Mus. [13322], pres. F. A. Cudmore.

Measurements.—6 mm. longitudinally, 9.5 laterally, elevation 4.5 mm.

Protolorica, n. gen.

Tail valve without anal sinus, and posterior extremity not upturned, having numerous pores or eyes on the inner margin of the lateral area, and immediately below the longitudinal ribbing of the pleural area. Type of genus, tail valve described below under the name *Protolorica atkinsoni*, Ashby.

PROTOLORICA ATKINSONI, n. sp.

(Plate XX., Figs 29*a,b*.)

Among the specimens loaned to me by Mrs. Atkinson is a tail valve that was taken by her late husband at Table Cape. The entirely different structure of this valve from that of the true *Loricas*, makes it necessary to provide a new genus for its reception. I consider it a primitive form through which the genus *Lorica* has been derived. When the description of *Lorica cudmorei*, Ashby, was written, the writer had not seen this tail valve, and at first, on receiving it from Mrs. Atkinson, intended associat-

ing it with that species, but on second thoughts concluded to make this valve the type of the new genus and attach to it a distinctive name, until such time as the production of new material may otherwise determine. We do not for certain know that this valve belongs to the same horizon as the median valves collected by Mr. Cudmore, which are described above. If in the future similar tail valves are met with in the same bed as *L. cudmorei*, then that species must be transferred to this genus, and *Protolorica atkinsoni* will be a synonym of *Protolorica cudmorei*.

Tail Valve.—Dorsal area eroded, pleural area is ornamented with 8 longitudinal ribs, all of which are furnished with a series of pores similar to those described in the median valves of *L. cudmorei*. A row of similar pores commencing at the mucro and extending to the outer margin, separates the lateral area from the pleural.

Mucro at the posterior margin, but not upturned, and posterior sinus absent. The lateral area is well defined, raised and decorated with radiating rows of rounded, elevated granules, commencing in three rows and a fourth being intercalated half way down the valve. Sutural laminae shallow, sinus narrow. The tegmentum is widely folded over at the mucro, the inside of the fold being longitudinally ribbed.

Measurements.—8.5 mm. longitudinally, 11.5 mm. laterally.

Locality.—Table Cape, Tasmania.

Age.—Miocene (Janjukian).

Genus *Loricella*, Pilsbry.

Sinus in tail valve a mere wave; jugal sinus lobed; girdle widest in front, not cleft behind. Ashby (Pap. and Proc. Roy. Soc. Tas. 1921, p. 39, pl. xv., fig. 4) describes and figures what he terms a "spade-like process," which is formed in the sinus, between the sutural laminae, by a forward extension of the articulamentum. This process is in the living forms slit on either side, to the tegmentum, and seems to be an important character of this genus.

LORICELLA GIGANTEA, Ashby and Torr.

(Plate XXI., Figs. 30, 31.)

(Trans. Roy. Soc. S. Austr., vol. xxv., pt. ii., pp. 137-138, pl. iv., fig. 3, 1901; *Loricella magnifica*, Hull, median valve, Proc. Linn. Soc. N.S.W., vol. xxxix., pt. 4, p. 856, 1915.)

Type Description.—"One specimen of anterior valve only.

"General Appearance.—Color dirty-white or wainscot-brown, shape exceptionally broad (nearly twice as broad as long), and very flat, anterior third of valve curved downwards, other two-thirds practically straight except at the apex, which is very slightly elevated.

"Sculpture.—Radially ribbed with very numerous, pronounced, bifurcating riblets, which are crossed by about 26 concentric wrinkles; while these are clearly defined, some are more so than others. These wrinkles break up the riblets into more or less pronounced granules. The eves [*sic*] only slightly overhang. Slits 18, at irregular distances. Margins of teeth are irregular, more crenulate than pectinate. The strong pectination of its congener, *Loricella Angasi*, Ad. and Ang., is quite absent, but the teeth are deeply grooved to their bases, very little indication of this being present in the living form. In *L. Angasi* a deep groove runs from each slit to the apex. In the fossil under review there is no groove, but its place is occupied by a slightly raised rib.

"Inside of Shell (Articulamentum).—The valve, except where stained, is paler than the tegmentum, a rib running from each of the slits to the apex, except that from the posterior slit, which is almost parallel with the posterior margin of valve.

"Measurement.—Length, 16 mm.; breadth, 33 mm.; elevation, $7\frac{1}{2}$ mm.

"Locality.—Morningside. [?].

"Remarks.—As compared with *Loricella Angasi*, the valve is much flatter, is convex instead of concave. The coarse radial ribs, nine or more in number, present in *L. Angasi*, are entirely absent, the riblets being evenly distributed over the whole valve. The largest specimen of *L. Angasi* known to us measures 68 mm. by 44 mm. This valve is fully one-fourth larger than the anterior valve of that specimen, and therefore we may conclude that when living this ancient form would have measured fully 85 mm. by 55 mm."

Median Valve.—This valve was described by Hull as *Loricella magnifica*, and associated with an anterior valve (l.c.); the sculpture exactly corresponds with the type valve of *L. gigantea*, Ashby and Torr, and this, taken in conjunction with the exceptionally low elevation of both valves, determines one to consider them conspecific.

I quote Hull's description of the sculpture with interpolations of my own. "Median valve: lateral areas strongly raised, irregularly sculptured with wavy lines [riblets]; central areas with similar but shallower lines, crossed by numerous faint grooves [or lines of growth]."

Measurement.—38 mm. laterally, where sutural laminae are complete; longitudinally, 10 mm.; elevation, 11 mm.

The anterior edge of the sutural lobe is worn and weathered, but there remains a notch on either side, which I believe are the bases of the slits on either side of the spade-like process.

Locality.—Table Cape, Tasmania.

Age.—Miocene (Janjukian).

Note.—The locality of Ashby and Torr's type is given as "Morningside." This is probably an error; it is much more likely that it came from Table Cape, in Tasmania, as there are fossils

from that locality in the same containing box. There is no original locality label, but a reference No. "18," is attached to the shell. This may have had reference to some catalogue of either Tate or Dennant. Hull (l.c.) omitted to signify which of the two valves he described under the name *Loricella magnifica* was his type. The anterior valve is too worn for determination, but obviously belongs to an elevated form, whereas the median valve well shows the sculpture in parts, and belongs to a species of exceptionally low elevation. I, therefore, designate Hull's median valve as his type, and consider it conspecific with *L. gigantea*, Ashby and Torr.

LORICELLA PAUCIPUSTOLOSA, (Ashby and Torr).

(Plate XXI., Figs. 32, 33; Pl. XXII., Figs. 34, 35, 36.)

(*Chiton paucipustulosus*, Ashby and Torr, Trans. Roy. Soc. S. Austr., vol. xxv., pt. ii., p. 141, pl. iv., fig. 2, 1901; *Loricella atkinsoni*, Hull, Proc. Linn. Soc. N.S.W., vol. xxxix., pt. 4, pp. 856-857, 1915; *Loricella octoradiata*, Hull, l.c.; *Loricella magnifica*, Hull, l.c., anterior valve only).

Type Description.—"One median valve from Table Cape. A well-preserved specimen.

"The Lateral Area is slightly raised, and contains a number of wavy transverse sulcations, or growth lines, extending into the pleural area. There are 12 to 14 small pustules on the anterior margin of the lateral area.

"Pleural Area.—The growth lines are very distinct in this area, and extend across the jugum. There are about 12 short longitudinal imbricating riblets, those nearest the jugum being the longest, and becoming shorter as they approach the centre of slope, those near the centre being mere elongated lumps. From the centre to the girdle they are absent.

"Length of dorsal area, 6 mm. Sinus wide, increasing from 2 to 4 mm. The sutural laminae are 3 mm., wide near the sinus, gradually lessening towards the girdle. The pectination of the teeth is fairly distinct.

"Measurement.—Width, 25 mm.; length of area, 6 mm.; divergence, 105°."

Hull was certainly correct in placing his *L. atkinsoni* under the genus *Loricella*. Ashby and Torr, when they described *paucipustulosus*, had only a median valve, whereas Hull had both anterior and median valves. Hull did not indicate which of these valves was his type. I therefore designate the median valve as his type of his *Loricella atkinsoni*, Hull, which name will stand as a synonym of *L. paucipustulosa*.

Median Valve.—Hull's type is now before me, and is obviously conspecific with Ashby and Torr's *paucipustulosus*; in Hull's type the marginal row of pustules is a little more clearly defined, and

the two rows surmount definitely raised ribs, but in his specimen the lateral area between the pair of radiating ribs appears concave, but is really of the same level as the rest of the valve; in all other respects it corresponds with the type valve of *paucipustulosus*; insertion plate and eaves well defined, slits 1/1, spade-like process in the jugal sinus well defined, as shown in Ashby and Torr's figure of their type.

Measurement.—Laterally, 22.5 mm.; longitudinally, 7 mm.

Anterior Valve.—Hull quite correctly associated the beautifully preserved anterior valve which he described under the name of *L. atkinsoni*, with his type of the median valve described under the same name. It is decorated with 10 evenly spaced, shallow radial ribs, two of which are close to the posterior margin, the other eight correspond with the slits. Each rib is surmounted by a single row of widely spaced, rounded granules, in all respects similar to the 2/2 rows present in the median valves. As pointed out by Hull, "the anterior third of slope [slightly] convex," from there to the apex the slope is steeper. There are a few granules in addition to those in the rows, close to the anterior margin.

Measurements.—Longitudinally, 12.5 mm.; laterally, 20 mm.; elevation at apex, 6 mm.

Loricella octoradiata, Hull (Proc. Linn. Soc. N.S.W., vol. xxxix., pt. 4, p. 856, 1915). The type valve is now before me, and measures laterally 22 mm. and 7.5 mm. elevation to the apex, the posterior margin is everywhere incomplete, so the longitudinal measurement cannot be given. In this single valve, upon which Hull founded his species, the whole of the tegmentum or upper shell has flaked off (with the possible exception of a fragment at one of the wings). None of the original sculpture is in existence; the radial markings described as ribs are the bases above which, in the living shell, the ribs had once been formed, but with the destruction of the tegmentum had entirely disappeared.

These bases are defined by a double row of pores, the shell structure between the rows being apparently different from that of the rest of the shell; in Hull's description they are spoken of as "prominent ribs," but as a matter of fact they are throughout most of their length, flat. Hull states that "the interspaces very finely sculptured with irregular V-shaped lines," he also shows these lines in his figure (l.c., pl. xciv., fig. 2); they are not sculpture as he supposes, but due to the structure of the interior layers of shell. The "V-shaped lines" evidently are channels for nerve fibres which after passing through the pores, margining the so-called ribs, branch off in fine bow-shaped grooves, terminating or dying away in the centre of the interspaces; a corresponding series of nerve-fibre channels branch off from the corresponding row of pores on the other side of the interspace; the double series of bent fibre channels, meeting along the central line, gives the V-shaped appearance mentioned by Hull as sculpture. The valve has eight slits corresponding with the "rib-bases" before

described, the slits seemingly having some relation with the system of distribution of the nerve fibres.

The shape of the valve, the number and position of the slits and corresponding rib-bases, entirely accord with the anterior valve of *Loricella paucipustulosa*, Ashby and Torr, with which species I consider it conspecific; therefore *L. octoradiata*, Hull, is a synonym of that species.

Loricella magnifica, Hull (l.c., p. 856, pl. xciv., fig. 1, anterior valve only.) As stated earlier, I consider that the anterior valve described by Hull under this name (which valve is now before me) is not conspecific with the median valve described by him at the same time under the same name. This anterior valve is very much worn, the whole of the sculpture having been eroded. Some of the slits are in evidence, the remaining indications suggest the number to have been 8, the number of ribs cannot be determined but was probably 10, of which 8 would correspond with the slits and the other two marginal ones. The shell is more elevated than either of the other two anterior valves of *paucipustulosa*, referred to above, but as the shell is larger than either, measuring longitudinally 15 mm., laterally 26 mm., and elevation, 11 mm., it seems likely that, while quite juvenile *paucipustulosus* may be flat, the elevation increases considerably with age. The subsidiary riblets referred to in Hull's description may not unlikely have been sub-cutaneous, as the upper layer of shell is absent. In the anterior valve of *paucipustulosa*, described above, there is a suggestion of very shallow intercalated riblets, but these certainly have no relation to the slits.

The very imperfect condition of this valve prevents accurate determination, but I have noticed no feature that warrants its separation from *Loricella paucipustulosa*, Ashby and Torr.

In conclusion,—This species is allied to the living form *Loricella torri*, Ashby, in that the anterior valve is furnished with 8 slits with corresponding shallow ribs surmounted with single rows of widely spaced, circular granules. I have one specimen from Port Jackson, measuring 5 mm., laterally, in the anterior valve, in which these ribs are almost identical with the fossil under discussion, and in this specimen the interspaces approach the fossil in smoothness, but the living form is certainly very variable, for in many specimens there are numerous intercalating riblets. In the median valves the living form differs widely, for longitudinal ribbing is always present, but absent in the fossil. Both the living forms, *L. angasi*, Ad. and Ang., and *L. torri*, Ashby, have 8 slits and the spade-like process in the jugal suture of the median valves in common with the fossil.

Locality.—Table Cape, Tasmania..

Age.—Miocene (Janjukian).

Pseudoloricella, n. sub-gen.

Ghitons in which the median valves are strongly sculptured, in general form corresponding with members of the genus *Loricella*

except for the fact that the sutural laminae are joined across the median line, the "spade-like process" occurring in the jugal sinus of the genus *Loricella* being absent.

LORICELLA (PSEUDOLORICELLA) SCULPTA, Ashby.

(Plate XXII., Figs. 37a,b.)

(*Loricella sculpta*, Ashby, Pap. and Proc. Roy. Soc. Tas., 1921, pp. 37-40, pl. xv., figs. 1-2.)

Introduction.—On page 39 (l.c.) in discussing the "spade-like process" which is present in the living forms of *Loricella*, occurs the following sentence: "The sinus or space separating the sutural laminae in the median valves (of *L. angasi* and *torri*), is very broad, with a deep slit at each side, this slit penetrating to the tegmentum, having a 'spade-like process' with a denticulate margin between the two slits."

"This feature is present in both the two living species, but in the fossil one under review these slits are entirely absent or rudimentary. It suggests that this feature may have been developed in recent times, in which case the fossil *Loricella* might very properly receive sub-generic distinction." Having now had the opportunity of examining all the types of fossils described as belonging to the genus *Loricella*, I have no hesitation in carrying out my earlier suggestion of providing a sub-genus for the reception of this species. *L. angasi*, *torri* and *paucipustulosa*, all have the spade-like process, and the anterior valve of each is furnished with 8 slits, but *L. gigantea*, Ashby and Torr, has a multi-fissate anterior valve, and although the unique median valve is too imperfect for accurate determination, it was, I think, furnished with the spade-like process, and therefore a true *Loricella*. The species described by the writer under the name *Loricella sculpta*, in addition to the absence of this feature, may, when the end valves are discovered, be found to possess other distinguishing characters.

Type Description.—"Up to the present one median valve only has been discovered in the Table Cape Beds, but it is in an excellent state of preservation; its beautiful sculpture, which suggests the name I am giving it, is as perfect as it was during life. The shell is remarkably flat, although carinated.

"Pleural and Dorsal Areas.—These are evenly decorated with narrow, strongly raised, wavy ribs; these in places are bridged by transverse ribs following the growth lines. These are particularly marked towards the anterior margin, where the transverse ribs resemble a string of small beads. Towards the posterior portion of the valve this feature of the sculpture is somewhat modified, and might be more correctly described as a series of irregularly and widely spaced grooves, following the growth lines and breaking to some extent the longitudinal ribs where they cross. These longitudinal ribs are more or less confluent on the jugum, and to a limited extent in the pleural area.

"Lateral Area.—This area is much raised and strongly decorated with coarse, radiating, wavy ribs; these are broken at irregular intervals by deep grooves, which are a continuation of the growth lines which cross the pleural area, and turn abruptly at less than a right-angle across the lateral areas.

"Inside.—Eaves well developed, insertion plates 1 slit, evidences of not very pronounced serrations. The sutural laminae are well developed, and appear to be much less produced forward than is the case with *L. angasi*, Ad. and Ang. [appearance due to the almost entire absence of sinus], the anterior margin throughout being almost straight, but in places it is a little broken; therefore, in a perfect shell, this feature may be less pronounced. The suture is broad, and the slits on either side thereof are absent. The anterior margin of the callus portion is almost straight, and the thickening very pronounced. The tegmentum is folded over the posterior margin in a similar manner to both *L. angasi*, Ad. and Ang., and *L. torri*, Ashby, with this difference, that in the fossil the margin is almost straight, whereas in the two species referred to, it curves outwards under the jugum, in a semi-circle.

"Note.—The strength and character of the sculpture easily separate this species from any other of the known fossil *Loricella*."

Locality.—Table Cape, Tasmania.

Age.—Miocene (Janjukian).

In Ashby and Torr's paper (l.c., pp. 142-4, 1901), several examples of fossil Chitons were described under generic names only, "sp.indet."; it seems desirable to refer to these, all of which have been placed in my hands for examination; each of these forms is designated in their paper under a number, which I now quote.

No. 10.—"*Lepidopleurus* sp.indet." This is described in this paper under the name *Lepidopleurus magnogranifer*, Ashby.

No. 11.—"*Ischnochiton* sp.indet." All six median valves are fragments of *Protochiton granulosus*, Ashby and Torr.

No. 12.—"*Chiton* sp.indet." Genus uncertain, possibly a *Lorica*.

No. 13.—"*Ischnochiton* sp.indet." Not *Ischnochiton*, possibly *Loricella paucipustulosa*, Ashby and Torr.

Nos. 14, 15 and 16.—"*Chiton* sp.indet." Genus quite uncertain.

No. 17.—"*Lorica* sp.indet." Genus correct; sp.indet.

No. 18.—"*Acanthochiton* sp.indet." Is *Afossochiton cudmorei*, Ashby.

No. 19.—"————." One specimen is a fragment of "*Protochiton granulosus*, the rest indet.

AUSTRALIAN FOSSIL PLACOPHORA.

Class AMPHINEURA.

Order POLYPLACOPHORA, Blainville.

Suborder EOPLACOPHORA, Pilsbry, 1900.

Family GRYPHOCHITONIDAE, Pilsbry, 1900.
(Palaeozoic forms; no Australian example yet found.)

Family LEPIDOPLEURIDAE, Pilsbry, 1892.

Genus *Lepidopleurus*, Risso, 1826.

LEPIDOPLEURUS MAGNOGRANIFER, Ashby, n. sp.

Family PROTOCHITONIDAE, Ashby, n. fam.

Genus *Protochiton*, Ashby, n. gen.

PROTOCHITON GRANULOSUS (Ashby and Torr, 1901).

= *Acanthochites granulatus*, Ashby and Torr, 1901.

Syn. *Ischnochiton (Ischnoplax) granulatus* of Chapman.

Suborder CHITONINA, Thiele, 1910.

Family ACANTHOCHITONIDAE, Hedley, 1916.

Subfamily AFOSSOCHITONINAE, Ashby, n. subfam.

Genus *Afossochiton*, Ashby, n. gen.

AFOSSOCHITON CUDMOREI, Ashby, n. sp.

A. ROSTRATUS, (Ashby and Torr, 1901).

= *Acanthochiton rostratus*, Ashby and Torr, 1901.

Subfamily ACANTHOCHITONINAE, Ashby, 1925.

Genus *Acanthochiton*, Gray, 1821, em.

ACANTHOCHITON CHAPMANI, Ashby, n. sp.

Subfamily CRYPTOPLACINAE, Thiele, 1910.

Genus *Cryptoplax*, Blainville, 1818.

CRYPTOPLAX PRITCHARDI, Hall, 1905.

C. GATLIFFI, Hall, 1905.

Family MOPALIIDAE, Pilsbry, 1892.

Genus *Plaxiphora*, Gray, 1847.

PLAXIPHORA CONCENTRICA, Ashby and Torr, 1901.

[*P. gellibrandi*, Ashby and Torr, 1901 = *P. albida*, Bl., recent.]

Family ISCHNOCHITONIDAE, Pilsbry, 1892.

Subfamily CALLISTOPLACINAE, Pilsbry, 1892.

Genus *Callistochiton*, Carpenter, 1882.

CALLISTOCHITON MERIDIONALIS, Ashby, 1919.

Family CHITONIDAE, Pilsbry, 1892.

Subfamily CHITONINAE, Pilsbry, 1892.

Genus *Chiton*, Linné, 1758.

Subgenus *Rhyssoplax*, Thiele, 1893.

CHITON (*RHYSSOPLAX*) FOSSICIUS, Ashby and Torr, 1901.

Subfamily LIOLOPHURINAE, Pilsbry, 1893.

Genus *Lorica*, H. and A. Adams, 1852.

LORICA COMPRESSA, Ashby and Torr, 1901.

L. COMPRESSA, var. *AFFINIS* (Ashby and Torr, 1901).

= *L. affinis*, Ashby and Torr, 1901.

Syn. *L. duniana*, Hull, 1910.

L. CUDMOREI, Ashby, n. sp.

Genus *Protolorica*, Ashby, n. gen.

PROTOLORICA ATKINSONI, Ashby, n. sp.

Genus *Loricella*, Pilsbry, 1893.

LORICELLA GIGANTEA, Ashby and Torr, 1901.

Syn. *Loricella magnifica* (median valve only), Hull, 1914.

L. PAUCIPUSTULOSA (Ashby and Torr, 1901).

= *Chiton paucipustulosus*, Ashby and Torr, 1901.

Syn. *Loricella atkinsoni*, Hull, 1914.

Syn. *L. octoradiata*, Hull, 1914.

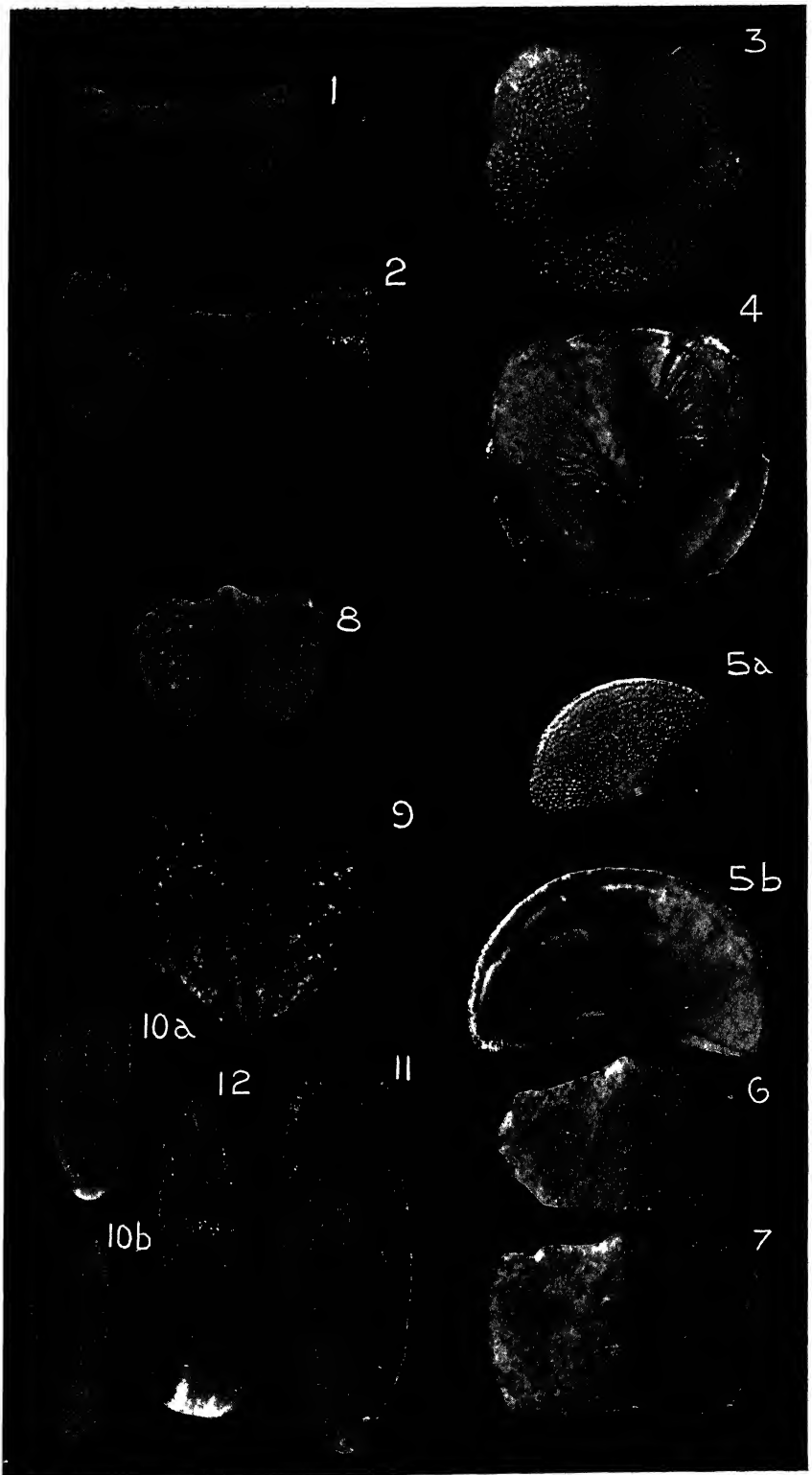
Syn. *L. magnifica* (anterior valve only), Hull, 1914.

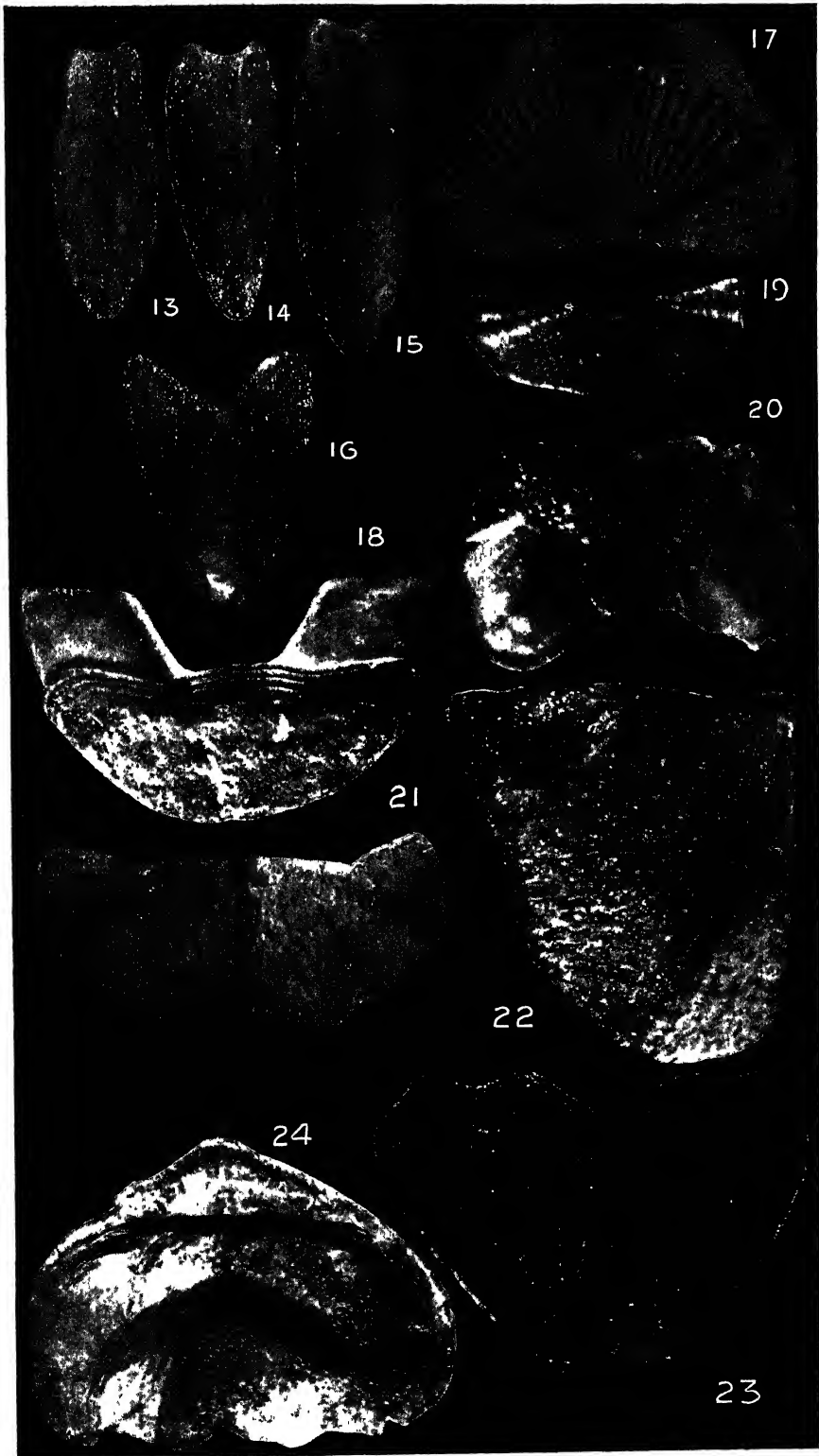
Subgenus *Pseudoloricella*, Ashby, n. subgen.

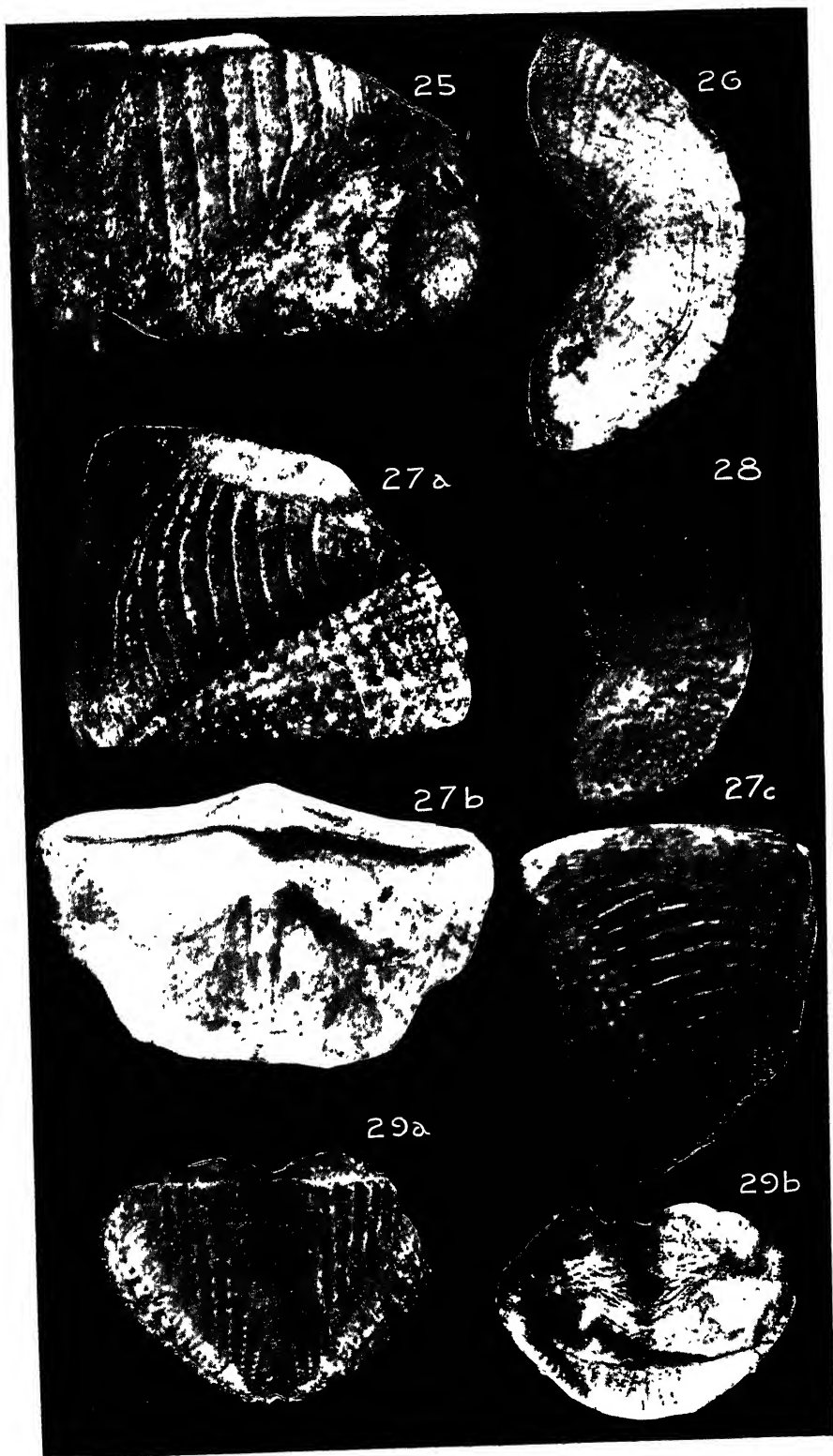
LORICELLA (PSEUDOLORICELLA) SCULPTA, Ashby, 1921.

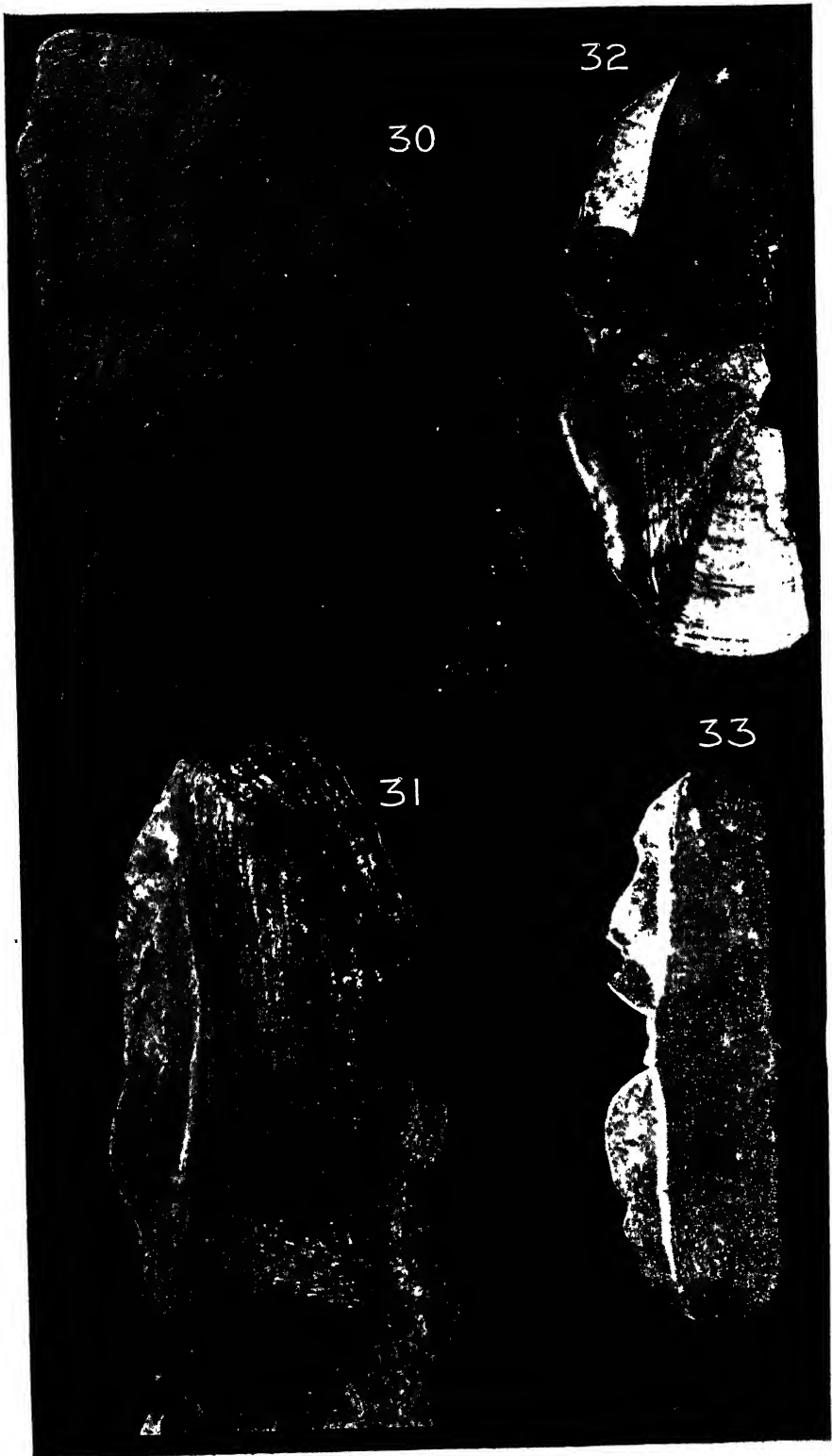
= *Loricella sculpta*, Ashby, 1921.

Note on Suborders and Superfamilies.—Pilsbry (Man. Conch., 1892), used three Superfamily names—(1) Eoplacophora, (2) Mesoplacophora, (3) Teleoplacophora; considering all Palaeozoic Chitons to belong to his family Lepidopleuridae. But in Zittel (l.c., 1900), he uses his name Eoplacophora as a subordinal name, with a new family which he calls Gryphochitonidae, to include all Palaeozoic species. Thiele (l.c., 1910), uses two subordinal names











—(1) *Lepidopleurina*, which equals Pilsbry's Superfamily *Eoplacophora*, 1892, and (2) *Chitonina*, to include all other forms of Chitons. I have followed him in this with some misgivings, for if, as we may anticipate, fossil forms are discovered later, completing the links between the Palaeozoic with those still living, under two parallel phyla, the introduction of these suborders will be seen to be artificial and misleading.

EXPLANATION OF PLATES.

PLATE XVIII.

- Fig. 1.—*Lepidopleurus magnogranifer*, Ashby. Muddy Creek; horizon unknown. Holotype, median valve. Tate Mus., University of Adelaide. $\times 7$.
- Fig. 2.—*Protochiton granulosus*, (Ashby and Torr). Balcombe Bay; Balcombian. Holotype of *Acanthochites granulosus*, Ashby and Torr, median valve. Tate Mus. $\times 6$.
- Fig. 3.—*Protochiton granulosus*, (Ashby and Torr). Balcombe Bay; Balcombian. Plesiotype, tail valve, upper side. Nat. Mus., Melbourne. [4840]. $\times 4$.
- Fig. 4.—*Protochiton granulosus*, (Ashby and Torr). Balcombe Bay; Balcombian. Plesiotype, tail valve, under side, showing callus ending of articulamentum and great extension of tegmentum. Ashby Coll. $\times 4$.
- Fig. 5.—*Protochiton granulosus*, (Ashby and Torr). Balcombe Bay; Balcombian. Plesiotype, here taken as type of anterior valve; insertion plate absent as in tail valve. Nat. Mus. [13310]. (a) upper side, $\times 4\frac{1}{2}$; (b) lower side, $\times 6$.
- Fig. 6.—*Afossöchiton cudmorei*, Ashby. Clifton Bank, Muddy Creek; Balcombian. Holotype, median valve. Nat. Mus. [13311]. $\times 6$.
- Fig. 7.—*Afossöchiton cudmorei*, Ashby. Clifton Bank, Muddy Creek; Balcombian. Paratype, median valve. Ashby Coll. $\times 6$.
- Fig. 8.—*Afossöchiton rostratus*, (Ashby and Torr). Balcombe Bay; Balcombian. Holotype of *Acanthochites rostratus*, Ashby and Torr, median valve. Tate Mus. $\times 6$.
- Fig. 9.—*Acanthochiton chapmani*, Ashby. Clifton Bank, Muddy Creek; Balcombian. Holotype, median valve. Nat. Mus. [13312]. $\times 5\frac{1}{2}$.
- Fig. 10.—*Cryptoplax gatliffi*, Hall. Clifton Bank, Muddy Creek, Balcombian. Holotype, showing oblong plate at apex. Nat. Mus. [13367.] (a) lower side; (b) oblique view, $\times 6\frac{1}{2}$.
- Fig. 11.—*Cryptoplax pritchardi*, Hall. MacDonald's, Muddy Creek; Kalimnan. Cotype, upper side. Nat. Mus. [13368]. $\times 6\frac{1}{2}$.

- Fig. 12.—*Cryptoplax pritchardi*, Hall. MacDonald's. Muddy Creek; Kalimnan. Cotype, side view, showing a very different form of valve, with apex turned over like the heel of a slipper. Nat. Mus. [13369]. $\times 6\frac{1}{2}$.

PLATE XIX.

- Figs. 13-15.—*Cryptoplax pritchardi*, Hall. MacDonald's, Muddy Creek; Kalimnan. Plesiotypes, three median valves varying in shape. Nat. Mus. [13313-5]. $\times 4$.
- Fig. 16.—*Cryptoplax pritchardi*, Hall. MacDonald's, Muddy Creek; Kalimnan. Cotype, upper side. Nat. Mus. [13370]. $\times 6\frac{1}{2}$.
- Fig. 17.—*Ischnochiton (Ischnoplax) pectinatus*, Sowerby. Recent. Median valve for comparison with *Protochiton granulosus*, (Ashby and Torr). Ashby Coll. $\times 6$.
- Fig. 18.—*Plaxiphora concentrica*, Ashby and Torr. Gellibrand; Janjukian (?). Holotype, tail valve. Tate Mus. $\times 3\frac{1}{2}$.
- Fig. 19.—*Callistochiton meridionalis*, Ashby. Forsyth's, Grange Burn; Kalimnan. Plesiotype, median valve. Nat. Mus. [13319]. $\times 6\frac{1}{2}$.
- Fig. 20.—*Acanthochiton coxi*, Pilsbry. Recent. Median valve, showing broad insertion plate with slit and sinus, for comparison with median valves of *Protochiton* and *Afossochiton*. Ashby Coll. $\times 6\frac{1}{2}$.
- Fig. 21.—*Chiton (Rhysoplax) fossicius*, Ashby and Torr. Table Cape; Janjukian. Holotype, median valve. Tate Mus. $\times 5\frac{1}{2}$.
- Fig. 22.—*Lorica compressa*, Ashby and Torr. Table Cape; Janjukian. Holotype, portion of median valve. Tate Mus. $\times 4$.
- Fig. 23.—*Lorica compressa*, Ashby and Torr. Table Cape; Janjukian. Plesiotype, showing upturned tail; here associated with *compressa* and taken as type of tail valve. Nat. Mus. [13320]. $\times 4$.
- Fig. 24.—*Lorica compressa*. Ashby and Torr. Table Cape; Janjukian. Plesiotype, median valve, lower side. Atkinson Coll., Nat. Mus. [13351]. $\times 3\frac{1}{2}$.

PLATE XX.

- Fig. 25.—*Lorica compressa*, var. *affinis*, (Ashby and Torr). Table Cape; Janjukian. Holotype, median valve. Tate Mus. $\times 4$.
- Fig. 26.—*Lorica compressa*, var. *affinis*, (Ashby and Torr). Table Cape; Janjukian. Plesiotype, here associated with *affinis*, and taken as type of anterior valve. Ashby Coll. $\times 4$.
- Fig. 27.—*Lorica cudmorei*, Ashby. Table Cape; Janjukian. Holotype, median valve. Nat. Mus. [13321]. (a) side

view, showing ornament, $\times 4$; (b) lower side, $\times 3\frac{1}{2}$; (c) side view showing complete curve of dorsal ridge, $\times 4$.

Fig. 28.—*Lorica cudmorei*, Ashby. Table Cape; Janjukian. Paratype, here associated with *cudmorei* and taken as type of anterior valve; compressed and elevated as compared with *affinis*. Nat. Mus. [13322]. $\times 4$.

Fig. 29.—*Protolorica atkinsoni*, Ashby. Table Cape; Janjukian. Holotype, tail valve. Ashby Coll. (a) upper side, showing non-upturned tail and large pore apertures, $\times 4$; (b) lower side, showing entire absence of anal sinus, $\times 3\frac{1}{2}$. Note.—Upper margin of Fig. 29b should be similar to that of Fig. 29a, the gap to left of centre being due to an error in retouching of a defect in the print.

PLATE XXI.

Fig. 30.—*Loricella gigantea*, Ashby and Torr. Table Cape (?); Janjukian. Holotype, part of anterior valve. Tate Mus. $\times 4$.

Fig. 31.—*Loricella gigantea*, Ashby and Torr. Table Cape; Janjukian. Holotype of *Loricella magnifica*, Hull, part of median valve; here associated with *gigantea*. Ashby Coll. $\times 4$.

Fig. 32.—*Loricella paucipustulosa*, (Ashby and Torr). Table Cape; Janjukian. Holotype of *Chiton paucipustulosus*, Ashby and Torr, median valve. Tate Mus. $\times 3\frac{1}{2}$.

Fig. 33.—*Loricella paucipustulosa*, (Ashby and Torr). Table Cape; Janjukian. Holotype of *Loricella atkinsoni*, Hull, median valve. Ashby Coll. $\times 4$.

PLATE XXII.

Fig. 34.—*Loricella paucipustulosa*, (Ashby and Torr). Table Cape; Janjukian. Anterior valve associated by Hull with holotype (here designated) of *atkinsoni*; here associated with *paucipustulosa* and taken as type of anterior valve. Ashby Coll. $\times 4$.

Fig. 35.—*Loricella paucipustulosa*, (Ashby and Torr). Table Cape; Janjukian. Holotype of *Loricella octoradiata*, Hull, anterior valve, showing a double row of pores corresponding with the ray-ribs of the upper shell of tegmentum, the V-shaped marking are the channels of nerve fibres connecting with the pores. Ashby Coll. $\times 4$.

Fig. 36.—*Loricella paucipustulosa*, (Ashby and Torr). Table Cape; Janjukian. Anterior valve associated by Hull with holotype of *magnifica*; a very worn shell, sculpture practically absent. Ashby Coll. $\times 4$.

Fig. 37.—*Loricella* (*Pseudoloricella*) *sculpta*, Ashby. Holotype of *Loricella sculpta*, Ashby, median valve. Ashby Coll. (a) upper side; (b) lower side, showing absence of spade-like process in sutural sinus. Both $\times 3$.

ART. XIII.—*Termites from the Australian Region: Descriptions of New Species and hitherto undescribed Castes.*

By GERALD F. HILL.

(Entomologist, National Museum of Victoria).

(With Plates XXIII.-XXVI.).

[Read 11th December, 1924].

Introduction.

In this paper nine species of Termites are proposed as new, of which number five are referred to the genus *Calotermes* and four to the genus *Eutermes*. In addition to these the alate caste of two species of *Eutermes* and the soldier caste of two species of *Calotermes* are described for the first time. A new name is proposed for a common Victorian species, which has been fully described and provisionally referred to *Calotermes obscurus* (Walker) in an earlier paper.

For the sake of uniformity with the papers of all students of Australian Termites excepting Walker (1853) and Hagen (1858), the generic name *Eutermes* has been retained for the group of species with nasute soldiers possessing reduced mandibles; it is intended, however, to adopt the inevitable change to *Nasutitermes* Banks later on when dealing with the group more comprehensively.

The method of recording measurements and colours is that adopted in earlier papers. The nomenclature of the wing-veins is that of Holmgren (1909). With the exception of Figs. 1 and 16, the outlines of thoracic nota have been drawn from balsam preparations; it is necessary, therefore, to make allowance for the effects of slight compression in the case of strongly arched sclerites, e.g., as in *Calotermes*.

In the preparation of this, and a more extensive paper now nearing completion, I have had the cordial assistance of Mr. J. A. Kershaw, Curator of the National Museum, who has been instrumental in obtaining material for study from the various Australian Museums, official entomologists, and from several field workers. I am also indebted personally to many well-known entomologists who, during the past twelve years, have rendered indispensable assistance in amassing and studying the unrivalled collection now at my disposal.

Systematic Descriptions.

CALOTERMES (CALOTERMES) RUFINOTUM, nov. nom.

C. obscurus Hill, non Walker. Proc. Linn. Soc. N.S.W., xlv. (4), 1921.

The possibility that the Victorian specimens described in the above paper might not be conspecific with Walker's species was suggested at the time. The rediscovery of the latter species in the type locality disposes of the doubt that has hitherto existed and renders it necessary to propose a new name for the eastern form, a full description of which was published in 1921.

Locality.—Victoria: Seaford (type loc.), Beaconsfield, Cockatoo, Lakes Entrance; New South Wales: Batlow.

The New South Wales specimens (all castes) were collected by Mr. W. W. Froggatt in a rotten log, where they were associated with *Porotermes adamsoni* (Frogg.).

Type imago and soldier in the National Museum of Victoria.

CALOTERMES (CALOTERMES) OLDFIELDI, n. sp.

(Plate XXIII., Figs. 1 and 2.)

Imago.

Colour.—Head and thorax Sandförd's-brown, tergites of abdomen ochraceous tawny, clypeus whitish, labrum orange, principal veins of wings cinnamon-brown, membrane hyaline, under surface and legs clay-colour.

Head.—With very few and very short setae, small, narrowed in front of eyes, widening behind the eyes to the broadly rounded posterior margin; frons depressed. Clypeus large, about four-fifths wider than long, sloping on the sides, anterior margin straight. Labrum large, markedly convex, narrowed at base, wide across middle and rounded in front, its orange colour contrasting strongly with the whitish clypeus and brown head. Eyes subtriangular, moderately large, (0.357 vertically×0.374 laterally) and prominent, 0.238 from lower margin of head. Antennae 19- or 20-jointed; 3rd joint larger and darker than 2nd and 4th.

Thorax.—Pronotum very large, anterior margin markedly concave, the border elevated, the sides rounded and slightly produced, posterolateral angles broadly rounded, posterior margin markedly concave, the setae very short and scanty.

Wings.—Short, the principal veins rather dark and bearing a few setae; radial sector generally with about four branches, but very variable; media very indistinct, in characteristic position for the sub-genus.

Measurements.—		mm.
Length with wings	- - - - -	15.25
Length without wings	- - - - -	8.75 — 9.25
Head, to apex of labrum, long	- - - - -	1.76 — 1.88
Head, to apex of clypeus, long	- - - - -	1.53 — 1.65
Head, wide	- - - - -	1.42
Pronotum, long, 1.19 — 1.25; wide	- - - - -	1.65 — 1.82
Wings, forewing, long, 11.00; wide	- - - - -	3.13
Tibia iii, long	- - - - -	1.42

Soldier.

Similar to *C. condonensis* Hill, from which species it differs in the following characters: Head shorter, wider and darker, mandibles shorter, stouter and more abruptly shouldered at the base (Fig. 1), anterior hyaline portion of clypeus large, as long as posterior dark portion (hardly visible in *C. condonensis*), labrum much larger, gula wider (Fig. 2), eyes larger, frons less concave, antennae, 13- 18-jointed, the joints somewhat shorter and narrower, pronotum more concave posteriorly, femora not so thick.

Measurements.—		mm.
Total length	- - - - -	11.50
Head, with mandibles, long	- - - - -	4.16 — 4.44
Head, to labral suture, long	- - - - -	2.85 — 3.19
Head, wide	- - - - -	1.76 — 1.88
Head, deep	- - - - -	1.42 — 1.65
Mandibles, from external articulation, long	- - - - -	1.53 — 1.71
Gula, at narrowest part, wide	- - - - -	0.37
Eyes, diameter	- - - - -	0.170 x 0.289
Pronotum, long, 1.42; wide	- - - - -	1.99 — 2.05
Tibia iii, long	- - - - -	1.36

The three soldiers in the type colony have rudimentary wings.

Locality.—Victoria; Kiata (type loc.), Bamawm, Keilor.

Described from a small colony collected by Mr. Robert Oldfield (July, 1924) in a branch of a Eucalypt 20 feet from the ground. The Bamawm and Keilor specimens, an alate imago in each case, were cut from rotten logs early in February.

Types and others in the National Museum of Victoria.

CALOTERMES (CALOTERMES) OBSCURUS (Walker).

(Plate XXIII., Figs. 3-7.)

Cat. Neurop. Ins. Coll. Brit. Mus., 1853; Hagen, Mon. der Termiten Linn. Entom., 1858 (*C. convexus* Walk.); Froggatt, P.L.S. N.S.W., xxi., 1896; Desneux, Gen. Insectorum, 1904 (*C. convexus* Walk.); non Hill, P.L.S. N.S.W., xlii., 1921 (*C. (?) obscurus* Walk.).

Through the courtesy of Dr. G. A. K. Marshall and Mr. B. Uvarov, specimens collected in the type locality (Swan River, S. W.A.) by Mr. J. Clark, have been compared with the damaged

type of Walker's species, and have been found to agree as far as comparison is possible. The species provisionally referred to *C. obscurus* by me (1921), and for which a new name (*C. rufinotum*) is proposed in this paper, is obviously quite a distinct species, though remarkably like it in the soldier caste.

The following are a supplementary description of the imago and a description of the hitherto undescribed soldier of *C. obscurus* (Walk.) :—

Imago.

Colour.—Head, pronotum and dorsum of abdomen dark chestnut to castaneous, the frons and middle of pronotum generally lightest; legs, labrum and sternites of abdomen clay-colour; wings cinnamon-brown, veins darker.

Head.—Small, with very few setae, markedly longer than wide, broadly rounded behind, nearly straight on sides; frons flattened, with a small concavity in the middle in line with the posterior margin of eyes. Eyes very small (0.238×0.255), subtriangular, finely faceted, hardly projecting, the lower margin a little more than their height from the lower margin of head. Ocelli rather large, nearly circular, contiguous with eyes. Clypeus small, arcuate in front. Labrum small, a little more than half as long as wide, markedly convex, rounded on sides, truncate in front, with scanty pale hairs on apical half. Antennae (Fig. 3) 14- or 15-jointed; 1st joint short and wide, three-fifths as wide as long; 2nd half as long as and one-fifth narrower than 1st; 3rd longer and wider than 2nd; 4th shorter than 3rd and about as wide; 5th a little longer and more rounded than 4th; 6th to 8th progressively longer.

Thorax (Fig. 4).—Pronotum strongly arched, with scanty pale setae, anterior margin concave, the sides slightly rounded and widening posteriorly, posterior margin parallel to anterior margin except in middle, where it is concave.

Wings.—Short and narrow, with minute setae on principal veins; venation variable; media always joining the radial sector beyond the middle, sometimes near its extremity; cubitus with many branches, these usually forked several times, the main stem often joining the radial sector a little beyond the junction of the media.

Measurements.—

		mm.
Length with wings	- - -	10.00 — 10.50; rarely 11.75
Length without wings	- - -	5.50 — 6.50; rarely 8.50
Head, to apex of labrum, long	- - -	1.36 — 1.48
Head, to clypeofrontal suture, long	- - -	1.08 — 1.14
Head, wide	- - -	1.14
Head, deep	- - -	0.80
Antennae, long	- - -	1.42
Pronotum, long	0.80 — 0.85; wide	1.25 — 1.36
Wings, long	6.50 — 7.00; wide	1.93 — 2.05
Tibia iii, long	- - -	0.97

Soldier.

Colour.—Ochraceous-orange, darker anteriorly, labrum and antennae same colour as back of head.

Head.—Long and narrow, less than half as wide as long (with mandibles), parallel on sides, frons sloping gently to clypeus; frontal and transverse sutures indistinct; antennal carinae heavily chitinated. Post-clypeus short, with a row of four setae near anterior margin; ante-clypeus half as long as post-clypeus, hyaline. Labrum wider than long, with sides slightly narrowed to the truncate apex, with fairly numerous reddish setae. Mandibles (Fig. 5) short and stout, with two teeth beyond the middle in left and three in the basal half of the right. Gula narrow. Antennae (Fig. 6) 14-jointed; 3rd joint longer, darker and more narrowed at the base than 2nd and 4th, or, 2nd longer and more quadrate than 3rd; 14th very small.

Thorax (Fig. 7).—Pronotum with scanty pale short setae, concave in front, sides nearly straight and widened posteriorly, posterior margin parallel to anterior margin except in middle, where it is concave. Posterior margin of meso- and metanotum truncate or slightly sinuate. (All the soldiers in some colonies have rudimentary wings.)

Measurements.—

	mm.
Total length - - - - -	6.50 — 8.50
Head, with mandibles, long - - - - -	2.40 — 3.70
Head, without mandibles, long - - - - -	1.71 — 2.45
Head, to anterior margin of clypeus, long - - - - -	2.16 — 2.67
Head, deep - - - - -	1.14 — 1.30
Head, wide - - - - -	1.14 — 1.42
Gula, at narrowest part, wide - - - - -	0.22
Pronotum, long 0.74 — 0.91; wide - - - - -	1.25 — 1.48

Locality.—West Australia: Swan River, Denmark, Ludlow.

Affinities.—From Hagen's statements it would appear that *C. convexus* (Walk.) and *C. improbus* Hagen are closely allied to, if not identical with, this species; specimens of these two Tasmanian species are not available for study, however. The soldiers from different colonies vary considerably in size, but there is little difference in individuals from the same community. The average size appears to be much nearer the maximum than minimum recorded above. The imagos also vary in size, as well as in colour, the majority being of the minimum size and darkest colour.

Type soldier, with associated imagos and nymphs, in the National Museum of Victoria.

CALOTERMES (GLYPTOTERMES) IRIDIPENNIS, Froggatt.

(Plate XXIII., Figs. 8 and 9.)

Proc. Linn Soc. N.S.W., xxi., 1896.

Queen.

Colour.—Head very dark-brown, nearly black; meso- and metanotum a little lighter; under surface, labrum, palpi and antennae

argus-brown; femora, tarsi and the last two sternites nearly as dark as mesonotum; anteclypeus hyaline, with ochraceous shading about the middle.

Head.—Finely shagreened, almost devoid of setae, those present confined to frons, broadly rounded behind and on sides to the eyes; frons slightly depressed in the middle, with minute furrows falling towards the centre. Eyes moderately large (0.342×0.342) and prominent, separated from the lower margin of the head by a space equal to half the diameter; lower margin of genae bent up as in pronotum. Ocelli small, broadly oval (0.114 long), close to, but not contiguous with, eyes. Postclypeus very short, paler than vertex, without setae, anterior margin slightly arcuate. Labrum short and very wide, about twice as wide as long, truncate in front, with very few setae. Antennae 15-jointed, 1.70 long.

Measurements.—

	mm.
Total length - king, 7.00 ; queen - - -	8.00
Head, to apex of labrum, long - - -	1.65 — 1.75
Head, to clypeofrontal suture, long - - -	1.25
Head, wide - - -	1.45
Pronotum, long 0.85 ; wide - - -	1.42
Tibia iii, long - - -	1.14

Soldier.

Colour.—Head vinaceous rufous; mandibles black, anteclypeus hyaline, tinged with ochraceous; labrum and antennae ochraceous; thorax, legs and abdomen buckthorn-brown.

Head (Fig. 8).—Nearly parallel on the sides, bluntly rounded behind, slightly narrowed to the prominent anterolateral angles; frons sloping at an angle of 45 degrees to the clypeus; clypeus and anteclypeus short, not conspicuous, the former bearing a few moderately long and stout setae, remainder of head excepting labrum almost hairless, the surface glabrous and minutely shagreened; labrum short and broad, with about twelve moderately long setae; gula (Fig. 9) much narrowed posteriorly, where it is one-fifth as wide as the head; antennae 13- to 15-jointed, generally 13-jointed; mandibles short and stout, each with three short, broad and inconspicuous teeth.

Thorax.—Pronotum (Fig. 8) a little more than twice as wide as long, reniform.

Legs.—Short and stout, femora thickened, nearly as wide as long.

Abdomen.—Tergites and sternites clothed as in imago, the sternites bearing also a few long, reddish setae; cerci short and stout; styli moderately slender.

Measurements.—

	mm.
Total length - - - - -	9.00 — 10.00
Head, with mandibles, long - - - - -	3.15 — 4.10
Head, without mandibles, long - - - - -	2.28 — 3.16

Head, to anterior margin of clypeus, long	-	-	2.33	—	2.73
Head, wide	-	-	1.48	—	1.76
Gula, at narrowest part, wide	-	-	0.28		
Pronotum, long	0.74	—	0.97		
	-	-	1.53	—	1.88
Tibia iii, long	-	-	1.25		

Locality.—Victoria: Frankston (type loc.), Melbourne, Belgrave (alate imago, 23/3/24), Beaconsfield; New South Wales: Dorrigo, Upper Lansdowne (2 alate imagos, 25/2/21).

Biology.—Although very destructive and fairly common, the only references in literature to this species relate to the type (imago); there are, however, several alate imagos and two series of soldiers and nymphs in the National Museum (collected in a suburb of Melbourne by the late F. P. Spry) from the trunk of a living ornamental tree (12-16/2/16). Through the courtesy of Mr. W. Laidlaw, Director of the Botanic Gardens, Melbourne, the National Museum has recently had opportunities of securing additional material from the trunks of two living trees (*Pyrus pashia* and *Agonis flexuosa*). The first series was collected on 12/6/24, and comprised two de-alated males, two de-alated gravid females, about 12 soldiers, and an immense number of nymphs in all stages of development. The oldest nymphs then had short, orange-rufous wing-pads, 13-jointed antennae, and faintly pigmented eyes. The second series was taken on 8/12/24, when soldiers and nymphs only were secured. The most advanced of the latter caste were apparently in the same stage of development as those taken six months earlier. The Beaconsfield colony, which was taken on 6/11/23, in the rotten sapwood of a Eucalypt felled some years earlier by saw-millers, appeared to be a young one; it comprised a de-alated male and female, one soldier and several hundred nymphs, all situated from ground-level upwards to a height of 3 feet. The oldest nymphs were then apparently in the same stage of development as those found on 12th June and 8th December. The Dorrigo specimens (collected by Mr. W. W. Froggatt) comprise soldiers and workers only, which agree with the Victorian specimens. The imagos from Upper Lansdowne (collected by Dr. E. W. Ferguson) are smaller than Victorian examples, but appear to be referable to this species.

Type soldier, with associated imagos and nymphs, in the National Museum of Victoria. The type imago cannot be definitely indicated, but it is unquestionably one of three specimens (collected by the late W. Kershaw at Frankston) in the same collection.

CALOTERMES (GLYPTOTERMES) CLARIPENNIS, n. sp.

(Plate XXIII., Figs. 10, 11 and 12.)

Colour.—Head russet; thorax and abdomen ochraceous-tawny; legs cinnamon-buff; wings hyaline, with anterior veins, base of media and cubitus tawny.

Head (Fig 10).—Small, narrow, shagreened, almost devoid of setae, frons depressed. Clypeus about two-thirds wider than long, with two pairs of long setae, sloping on the sides, broadly truncate in front. Labrum light orange-yellow, large, about twice as wide as long, convex, narrowed at base, markedly swollen on sides. Eyes moderately large and prominent, subtriangular (0.323 vertically×0.272 horizontally), 0.204 from lower margin of head. Ocelli large (0.119 long), broadly oval, close to eyes. Mandibles (Fig. 11), left with apical tooth larger than subapical, the latter followed by a broad triangular tooth about as long as the subapical one; right with apical tooth similar to that of left; the subapical tooth equally long, but wider, the following tooth wide and occupying more than one-third the width of the mandible. Antennae 13- or 14-jointed; 1st joint short and stout; 2nd, about half as long and much narrower; 3rd longer than 2nd (sometimes markedly so), narrower at base, wider at apex, rarely equal to 2nd; 4th about as long as 2nd, rounded; 5th and succeeding joints larger than 4th; apical joint shorter and narrower than preceding one.

Thorax (Fig. 12).—Pronotum about as wide as head, concave in front, rounded on sides and in front, the anterior margin slightly elevated, a deep impression on either side behind the raised margin, sides and posterior margin produced and fringed with scattered pale setae, longest on the anterolateral angles and sides. Posterior margin of meso- and metanotum concave, a dark brown median line through the anterior half of the sclerite.

Wings.—Costa and subcosta very short, the radial sector and media running parallel and very near the costal border to near the apex of the wing; cubitus very obscure, excepting at the base, the main stem traversing the wing just above the middle, with about twelve branches, only the first of which is well defined; anales with about six or eight branches; a few setae on anteriormost veins; scale-like papillae very obscure.

Legs.—Short and stout, with scattered, mostly short, stout setae; femora thickened, those of hind leg nearly half as wide as long; spurs long, finely serrated; claws long and moderately stout.

Abdomen.—Segments fringed apically with scanty, long pale setae; cerci and styli moderately large.

Measurements.—

	mm.
Length with wings - - - - -	9.50 — 10.00
Length without wings - - - - -	5.50 — 6.00
Head, to apex of labrum, long - - - - -	1.19 — 1.36
Head, to clypeofrontal suture, long - - - - -	0.97 — 1.08
Head, wide - - - - -	1.08
Pronotum, long 0.62; wide - - - - -	0.97 — 1.08
Wings, forewings, long 7.75; wide - - - - -	2.05
Wings, hindwings, long 7.50; wide - - - - -	2.16
Tibia iii, long - - - - -	0.85

Locality.—Lord Howe Island (A. Musgrave and G. Whitley, December, 1923).

Type imago, and associated nymphs in the Australian Museum, Sydney (No. K48725); paratypes in the National Museum of Victoria.

CALOTERMES (CRYPTOTERMES) ARCANUS, n. sp.

(Plate XXIII., Figs. 13, 14 and 15.)

Imago.

Similar to *Calotermes (Cryptotermes) primus* Hill, from Townsville, N.Q., from which species it may be distinguished by its larger size, darker and longer wing and much darker antennae. Antennae (Fig. 13) 16- or 17-jointed, suffused with dark brown. Wings tawny-olive; costa, radius and radial sector darker; a few minute setae on radial sector and distal one-third of costa; membrane covered with scale-like papillae; radial sector with 7 or 8 superior branches; media very indistinct except at base, joining radial sector about the distal one-third of wing, the junction not always thickened; cubitus with about 14 branches, the distal 7 or 8 indicated by rows of scale-like papillae, the main stem sometimes joining the radial sector about midway between the junction of the media and the apex of the wing, the extremity thickened when thus terminated.

Measurements.—

	mm.
Length with wings - - - - -	10.00 — 10.50
Length without wings - - - - -	5.00
Head, to apex of labrum, long - - - - -	1.14
Head, to clypeofrontal suture, long - - - - -	0.91
Head, wide - - - - -	0.97
Eyes, 0.255 — 0.272 vertically \times 0.306 — 0.323 horizontally.	
Eyes from lower margin of head - - - - -	0.17
Pronotum, long 0.51; wide - - - - -	1.02
Wings, long 8.25; wide - - - - -	2.28

Soldier.

Similar to *Calotermes (Cryptotermes) primus*, but differentiated by its larger head, anterior margin of frontal flange without emargination or furrows, and not overhanging the frons in the middle, although very prominent on the sides, the dorsal surface of head with much deeper impression behind the frontal flange, pronotum with anterior margin similarly thickened, and serrate, but the emargination more obtuse.

Measurements.—

	mm.
Total length - - - - -	4.00 — 4.50
Head, from base to frontal flange, long - - - - -	1.14
Head, wide - - - - -	1.14
Head, deep - - - - -	0.85
Pronotum, long, 0.80; wide - - - - -	1.08
Tibia iii, long - - - - -	0.57

Locality.—Lord Howe Island (A. Musgrave and G. Whitley, 10/12/23).

Type imago, soldier and associated nymphs in the Australian Museum, Sydney (No. K48724); paratypes in the National Museum of Victoria.

CALOTERMES (CRYPTOTERMES) SECUNDUS, n. sp.

(Plate XXIII., Fig. 16.)

Soldier.

Colour.—Yellow behind, darkening anteriorly to the frontal flange, which is nearly black; mandibles castaneous; pronotum, antennae, labrum same colour as base of head.

Head (Fig. 16).—Very short and wide, shagreened, with scattered long setae; frontal flange prominent, especially on sides, broadly emarginate when viewed from front or from behind, with two shallow furrows on each side of the middle; frons excavated, rugose, sloping to the base of clypeus, a prominent vertical ridge on each side in line with lateral margins of clypeus, and extending upwards from the clypeofrontal suture to the frontal flange; lower lateral margins of head prolonged to form a blunt, horn-like projection directed upward and forward at an angle of 45 degrees with the axis of head, and hardly reaching the apex of second antennal joint, above this projection there is another similar but shorter one arising as a prolongation of the antero-dorsal margin of the antennal foveola. Clypeus short and very wide (0.49), its anterior margin cream-colour, slightly arcuate. Labrum short and wide, light orange-yellow, with a group of moderately long, pale setae in the middle. Antennae 13-jointed; 1st joint short and stout, widest at apex; 2nd more than half as long as 1st and one-sixth narrower; 3rd about as long as 2nd and very little wider; 4th and 5th a little more than half as long as 2nd and 3rd and less narrowed at base; 6th and 7th a little longer and about as wide as 4th and 5th, but more globose.

Thorax.—Cervical sclerites scarcely darker than base of head. Pronotum with anterior margin thickened and dark in colour, markedly convex in middle, indistinctly serrate, slightly elevated in the middle, and markedly raised towards the sides, the anterolateral corners, sides and posterolateral corners rounded, posterior margin slightly sinuate in the middle, with scanty moderately long setae.

Legs.—Short and stout; spurs serrate.

Measurements.—

	mm.
Total length (dried specimen) - - - - -	4.50
Head, with mandibles, long - - - - -	1.99
Head, posterior margin to frontal flange, long - - - - -	1.14
Head, wide - - - - -	1.19
Head, deep - - - - -	0.85
Pronotum, long 0.85; wide - - - - -	1.14
Tibia iii, long - - - - -	0.70

Locality.—Northern Territory: Darwin.

Affinities.—Allied to *Planocryptotermes nocens* Light (paratype examined), but distinguished, *inter alia*, by the presence of vertical ridges on frons and differently shaped frontal flange. From *C. (Cryptotermes) primus* Hill it differs as above, and in having the anterior margin of the pronotum less angulate, and less serrate and the sides more narrowed to the posterior margin.

Described from a small colony found in the trunk of a living coconut palm previously damaged by weevils (*Diocalandria*), (G.F.H., 8/5/13). A second colony, comprising only young nymphs and larvae, was found in the stem of an indigenous shrub (dead) at East Point, near Darwin (G.F.H., 13/10/15). In both instances only a small area of the host-plant was affected, and, as is the rule with *Cryptotermes*, there was no communication with the ground.

Type soldier and associated nymphs in the National Museum of Victoria.

EUTERMES APIOCEPHALUS Silvestri.

(Plate XXIV., Figs. 17-20.)

Die Fauna Südwest-Australiens, 1909. Mjöberg, Arkiv för Zoologi, Bd. 12, No. 15, 1920.

Imago.

Colour.—Nearly black; antennae, abdomen and legs a little lighter than head and pronotum; clypeus auburn; wings sooty black; apex of tibiae and the tarsi pale.

Head (Fig 17).—Small, glabrous, moderately setaceous, hemispherical behind the eyes, frons flattened. Fontanelle small, lying in a deep depression, its shape not well defined, but apparently oval. Eyes rather small (0.272—0.289 diam.), finely faceted, moderately prominent, about 0.085 from lower margin of head. Ocelli oval, very prominent, small (0.102 long), separated from the eyes by a space equal to their length. Postclypeus dark, but distinctly lighter than head, with darker suture, markedly convex and glabrous, hemispherical behind, truncate in front, a little more than half as long as wide; anteclypeus hyaline suffused with yellow, large, a little less than half as long as postclypeus, produced in the middle, rounded in front. Exposed basal part of mandibles yellow, dentition as shown in Fig. 18. Antennae (Fig. 19) long, 15-jointed; 1st joint nearly twice as long as wide; 2nd almost cylindrical, half as long and much narrower than 1st, 3rd half as long as 2nd, and very narrow, smallest of all; 4th as long as 2nd and a little wider, broadly oval; 5th noticeably shorter and narrower than 4th; 5th-9th progressively longer; 9th-13th almost equally long; 14th longer and more cylindrical than 13th; 15th about as long as 14th, elongate oval.

Thorax (Fig. 20).—Pronotum moderately setaceous, short and wide, the anterior margin sinuate and markedly raised behind the

extreme edge, the anterolateral corners narrowed, a deep impression on either side of the median line behind the raised anterior margin, another, but shallower, impression in the middle line near the posterior margin, the sides sloping sharply to the markedly sinuate posterior border. Posterior margin of meso- and metanotum strongly emarginate.

Wings.—Very dark in colour, the radial sector very distinct, and with numerous setae to its extremity; distal four-fifths of media, the branches of the cubitus (excepting the proximal eight or nine) very indistinct.

Legs.—Moderately long and slender.

Abdomen.—Cylindrical, very setaceous, the setae short and pale; cerci short and stout.

Measurements.—

	mm.
Length with wings	10.00
Length without wings	6.00
Head, to apex of labrum, long	1.3
Head, to clypeofrontal suture, long	0.62 — 0.68
Head, wide	1.08
Antennae, long	1.53 — 1.65
Pronotum, long	0.54; wide 1.00
Tibia iii, long	1.08
Wings, forewings, long	7.50 — 8.00; wide 2.00 — 2.16
Wings, hindwings, long	7.25 — 7.50; wide 2.20 — 2.32

Queen.

Total length, 13.00; abdomen, wide, 4.00.

Locality.—South-west Australia; Hovea, Gosnell's, Pinjarra, Armadale, Boyanup, Kelmscott (J. Clark), Mundaring (J. Clark and C. F. Hill).

Identification.—The identification of this species is based upon a comparison of soldiers and workers from Hovea which were identified for me by Professor Silvestri with the soldiers and workers in several complete nest series from the above localities. I have seen no soldiers with antennae quite agreeing with that figured by Silvestri, though antennae with the 3rd joint only slightly larger than the 2nd are common. In one example only the 3rd joint is shortest of all, in all others the 4th is shortest, and the 2nd and 3rd are about equal. I have no doubt whatever that the species here described as *E. apiocephalus* Silv. is conspecific with *E. aagaardi* Mjob. (type locality Mundaring).

Type imago and associated soldiers and workers in the National Museum of Victoria.

EUTERMES WESTRALIENSIS Hill.

(Plate XXIV., Figs. 21-24.)

Proc. Linn. Soc. N.S.W., xlvii., 1921.

Imago.

Colour.—Head and pronotum nearly black; legs, basal half of antennae, postclypeus and abdomen a little lighter; apical half of

antenna and the tarsi light yellowish brown like base of mandibles; basal half of labrum a little lighter than base of mandibles, apical half hyaline; wings dark brown.

Head (Fig. 21).—Small, flat on summit, markedly glabrous, the setae scanty and mostly very small. Clypeus small, markedly convex, a little more than twice as wide as long (0.272×0.595), very little lighter in colour than summit of head; anteclypeus short, slightly produced in the middle. Labrum about as long as clypeus, widest across middle, broadly rounded in front. Eyes small (0.255×0.289), very prominent, finely faceted, separated from the lower margin of the head by a space less than that separating ocelli from eyes. Ocelli small, elongate-oval, widely separated from eyes, i.e., by a space exceeding their length. Antennae (Fig. 23) 16-jointed; 1st joint large and dark coloured, twice as long and two-thirds wider than 2nd; 3rd short and narrow; 4th noticeably wider and more globose than 3rd; 5th markedly longer and wider than 4th and 6th, as large as 7th; 7th to 15th about equal in length; 16th, a little shorter and narrower than 15th, oval. Mandibles as shown in Fig. 22. Fontanelle moderately large, conical behind, strongly forked anteriorly.

Thorax (Fig. 24).—Pronotum small, with scanty, rather short yellow setae, much narrower than head, with a deep impression on either side of the median line behind the markedly raised anterior margin, the latter nearly straight when viewed from above, antero-lateral angles rounded, the sides narrowed to the slightly sinuate posterior margin. Posterior margin of meso- and metanotum widely emarginate.

Wings.—The radius, radial sector, and first four to six branches of cubitus dark, the media and remaining branches of cubitus instinct, the border, principal veins and membrane very setaceous.

Legs.—Moderately long and slender, moderately setaceous, tarsi markedly paler than tibiae and femora; claws and spurs long and slender.

Abdomen.—Short and wide, moderately densely clothed with short setae.

Measurements.—

	mm.
Length with wings - - - - -	11.50 — 12.00
Length without wings - - - - -	5.50 — 6.00
Head, to apex of labrum, long - - - - -	1.42
Head, to clypeofrontal suture, long - - - - -	0.80
Head, wide - - - - -	1.19
Antennae, long - - - - -	2.00
Pronotum, long 0.62; wide - - - - -	0.91
Wings, forewings, long, 9.50; wide - - - - -	2.56
Wings, hindwings, long, 9.25; wide - - - - -	2.67
Tibia iii, long - - - - -	1.42

Locality.—West Australia: Gosnell's, Armadale, Mundaring (J. Clark).

Described from a long series of alate imagos from the type locality (Gosnell's), the associated soldiers and workers of which have been compared with the types of these castes. Alate forms were taken on 12th March.

Affinities.—The imago bears a striking superficial resemblance to *E. apiocephalus* Silv., from which species it is easily distinguished by its larger size, lighter wings, one more joint in the antennae and much narrower and less angulate pronotum. The respective soldiers and workers of these two species cannot be confused.

Biology.—Mr. Clark informs me that on the hills this species tunnels in the ground under stones, where stores of grass cut into short lengths are to be found. The mounds are described in the paper referred to above.

Type imago, soldier and worker in the National Museum of Victoria.

EUTERMES PERACUTUS, n. sp.

(Plate XXIV., Figs. 25 and 26.)

Soldier.

Colour.—Head, basal half chestnut shading into very dark brown anteriorly; basal three-fifths of rostrum nearly black, apical two-thirds lighter than base but darker than base of head; 1st joint of antennae like apex of rostrum, the following joints, excepting the last two or three, dark (Prout's) brown; thorax and abdominal tergites Prout's brown, femora a little lighter, tibiae and tarsi distinctly lighter; sternites of abdomen tawny-olive. Smaller form of soldier generally similar to the larger, but lighter coloured throughout.

Head (Fig. 25).—Very long and narrow, widest about the basal one-third, then narrowed sharply to the base of rostrum, where it is slightly constricted and much darker in colour; rostrum very long and narrow, a little shorter than remainder of head, with a group of setae on dorsal surface about the middle and more setae towards the apex. Antennae (Fig. 26) 13- or 14-jointed; when 13-jointed the 3rd joint markedly longer than the 2nd and 4th, and generally with a slight constriction before the middle; when 14-jointed the 3rd shorter than 4th; the joints otherwise very long and slender.

Thorax.—Pronotum very small, of the usual form, very dark in colour, excepting for a transverse pale band behind the upturned anterior half; with very few setae.

Legs.—Long and slender, moderately setaceous, the femora and extreme base of tibiae distinctly darker than the remainder of the tibiae and the tarsi.

Abdomen.—Narrow at base, wide in middle and pointed at apex; tergites glabrous, with very scanty fringe of moderately long setae at the apex of each.

Measurements.—	Small form. mm.	Large form. mm.
Total length - - - -	3.25	4.25
Head, to apex of rostrum, long -	1.42 — 1.53	1.70 — 1.82
Head, wide - - - -	0.68	0.85 — 0.88
Head, deep - - - -	0.40	0.57
Antennae, long - - - -		1.88 — 2.05
Pronotum, long - - - -	0.20	0.25
Pronotum, wide - - - -	0.35	0.52
Tibia iii, long - - - -	0.96	1.14

The small form appears to differ from the larger one in colour and size only.

Worker.

Colour.—Head at base chestnut (shade darker than in soldier), deepening anteriorly to dark (Prout's) brown; antennae brown at base, yellow towards apex; clypeus distinctly lighter than antennae; labrum light orange-yellow; thorax and abdominal tergites mummy-brown to Dresden-brown, the former with a distinct median pale line passing through it; legs and under surface whitish.

Head.—With very few setae, widest at the genae, rather sharply narrowed posteriorly; sutures pale and very distinct; frons depressed, with a deep impression on either side of the middle; postclypeus small, two-fifths wider than long, hemispherical behind, truncate in front, with indistinct median suture and very few setae, the latter near anterior margin; anteclypeus hyaline, large, markedly produced in front, nearly as long as postclypeus. Labrum small, narrow at base, very much wider in the middle and rounded in front. Antennae 14- or 15-jointed, variably segmented as in soldier.

Thorax.—Pronotum small, about half as wide as head, somewhat similar to that of soldier, the anterior half rounded in front, with distinct emargination, the whole surface with scattered moderately stout setae, longest and most numerous towards the anterior border.

Legs.—Long and slender, moderately setaceous.

Abdomen.—Large, narrow at base and apex, widest in middle, the tergites glabrous, moderately setaceous and conspicuously dark in colour; sternites very pale, suffused with yellow or brown; cerci large.

Measurements.—	Small form. mm.	Large form. mm.
Total length - - - -	5.00	5.75 — 6.00
Head, to apex of labrum, long -	1.48	1.76
Head, to clypeofrontal suture, long -	0.96	1.02
Head, wide - - - -	1.25	1.36
Antennae, long - - - -	..	1.93
Pronotum, long - - - -	..	0.37
Pronotum, wide - - - -	..	0.54
Tibia iii, long - - - -	..	1.23

Locality.—West Australia: Beverley (Type loc.), York, Chidlow's Well (J. Clark), Merredin (L. J. Newman).

Affinities.—Most closely allied to *E. tumulus* Froggatt, from which species the smaller soldier is distinguished, *inter alia*, by a narrower and slightly constricted head, the dorsal surface (in profile) of which is markedly depressed in the middle (not nearly straight, as in *E. tumulus*), and markedly longer jointed antennae. A large form of soldier is unknown in the last-mentioned species. The dark colour of the soldier and worker, and especially the very dark rostrum of the former caste, are striking features of the proposed new species.

Biology.—Mr. Clark states that this species does not build mounds but tunnels in the soil under large stones. It is a grass-cutting species.

Type soldier and worker in the National Museum of Victoria.

EUTERMES CENTRALIENSIS, n. sp.

(Plate XXIV., Figs. 27-29.)

Soldier.

Colour.—Head ochraceous-tawny to russet, rostrum dark bay, anterior part of pronotum and tergites, of abdomen cinnamon-brown.

Head (Figs 27 and 28).—Moderately large, spherical in dorsal aspect, with very few setae, rostrum short and moderately stout, about one-third as long as remainder of head; dorsal surface of head in profile nearly straight. Antennae (Fig. 29) 13-jointed, the joints moderately long and slender; 2nd joint shorter than 3rd, very little shorter than 4th; 5th and remaining joints long and slender; 13th a little shorter than 12th.

Thorax.—Pronotum small, of usual form, the anterior half dark; with few setae.

Legs.—Long and slender.

Abdomen.—Dark in colour; with few setae except towards the apex.

Measurements.—

mm.

Total length	-	-	-	-	-	-	-	4.00
Head, long	-	-	-	-	-	-	-	1.70 — 1.82
Head, wide	-	-	-	-	-	-	-	1.14 — 1.19
Head, deep	-	-	-	-	-	-	-	0.68 — 0.74
Pronotum, long	0.28;	wide	-	-	-	-	-	0.62
Tibia iii, long	-	-	-	-	-	-	-	1.14

Worker.

Colour.—Dorsum of head tawny, with very distinct sutures; vertex and genae light buff; frons suffused with tawny, transverse suture indicated by a broad pale line much wider than

frontal suture; clypeus and labrum pale orange-yellow; a dark reddish spot at each end of the former; thorax and abdominal tergites light tawny-olive.

Head.—Almost devoid of setae, widest behind the insertion of antennae, narrowed to the broadly rounded posterior margin; frontal suture narrow, widening out anteriorly to form a triangular pale area bounded by the transverse suture. Postclypeus small, strongly convex, less than half as long as wide, with obscure median suture and very few setae; anteclypeus about half as long as postclypeus, markedly produced in front. Labrum small, shorter than clypeus, narrow at base, widest behind the middle, narrowed to the bluntly pointed apex, with very few setae. Antennae 14-jointed; 4th joint slightly shorter than 2nd, 3rd and 5th, or 2nd, 3rd and 4th equal and 5th a little longer, or 3rd markedly longer than 2nd and 4th.

Thorax.—Pronotum much narrower than head, anterior half bent up and narrowed to the deeply notched anterior border, with very few and very short setae.

Legs.—Moderately short and stout, with few setae; claws short.

Abdomen.—With few setae, these very short except on venter, where some are long.

Measurements.—

	mm.
Total length - - - - -	4.50 — 5.00
Head to apex of labrum, long - - - - -	1.45 — 1.50
Head, to clypeofrontal suture, long - - - - -	0.93
Head, wide - - - - -	1.14 — 1.25
Pronotum, long 0.28; wide - - - - -	0.68

First-form nymph.

Total length, 5.75; head, long, 1.02; head, wide, 0.97; pronotum, long, 0.45; pronotum, wide, 0.85; antennae, 15-jointed; pronotum, with anterior margin markedly elevated, corners rounded and sides narrowed to the wide and obscurely emarginate posterior margin; wing-buds faintly suffused with brown.

Locality.—Central Australia (Drs. Horne and Nicholls).

Affinities.—From *E. pyriformis* Frogg. the soldier differs, *inter alia*, in having the head and body markedly less setaceous, the rostrum shorter and of uniform colour, antennae 13- (not 14-) jointed, antennal joints distinctly shorter. From *E. longipennis* Hill it differs in having a larger and less setaceous head, one joint less in the antennae, and the segmentation different.

Type soldier and worker in the National Museum of Victoria.

EUTERMES EXITIOSUS, n. sp.

(Plate XXV., Figs. 30-35.)

Imago.

Colour.—Head dark chestnut-brown; postclypeus, labrum, antennae, thorax, legs and venter yellow-ochre to clay-colour;

wing-stumps mummy-brown; tergites of abdomen clay-colour, much suffused with brown; wings mummy-brown at base, lighter towards apex, anterior margin clay-colour.

Head (Fig. 30).—Moderately large, depressed behind the clypeus, broadly rounded behind, moderately setaceous. Eyes large ($0.342 - 0.375 \times 0.400 - 0.450$) and prominent, close (0.085) to lower margin of head. Ocelli very large, broadly oval (0.102×0.153), about half the distance from the eyes that the latter are from the lower margin of head. Fontanelle small, but distinct, linear, forked anteriorly. Postclypeus large, less than half as long as wide (0.255×0.630), much lighter than head, with median suture indistinct and with few setae; anteclypeus hyaline, about one-third the length of postclypeus, sides sloping slightly to the anterior margin, which is but little produced in the middle. Labrum small, rather setaceous, about as long and wide as clypeus, narrow at base, widest across middle. Antennae (Fig. 31) long and moderately stout, 15-jointed; 1st joint a little longer than half its width; 2nd as long as 1st is wide, slightly narrowed at base; 3rd one-fifth shorter and a little narrower than 2nd; 4th slightly longer and noticeably wider than 3rd; 5th as long as but narrower than 4th, wider than 3rd; 6th a little longer, wider and narrower at the base than 4th; 6th-14th increasing in length progressively, but very gradually; 15th shorter than 14th, elongate-oval.

Thorax (Fig. 32).—Pronotum a little narrower than head, slightly situate in front, the anterior margin bent up and slightly notched, two deep impressions on either side, one in the anterolateral angle and a deeper one between it and the median line, anterolateral angles rounded, sides narrowed sharply to the moderately sinuate posterior margin, setaceous, some of the setae conspicuously longer than the majority. Posterior margin of meso- and metanotum wide and more obtusely emarginate than pronotum.

Wings.—Very large, with numerous setae on membrane, all veins excepting the distal half of media and last two or three branches of cubitus very distinct, the costal margin beyond the middle distinctly yellow; cubitus with about 6 branches in forewing and eight in hindwing, the distal branches sometimes forked once or twice.

Legs.—Long and moderately stout and hairy.

Abdomen.—Large, broad, broadly rounded at apex, very setaceous; cerci moderately large.

Measurements.—

	mm.
Length with wings - - - - -	25.00 — 26.50
Length without wings - - - - -	6.50 — 7.00
Head, to apex of labrum, long - - - - -	1.42
Head, to clypeofrontal suture, long - - - - -	0.80
Head, wide - - - - -	1.19 — 1.25
Antennae, long - - - - -	2.00
Pronotum, long, 0.74; wide - - - - -	1.14
Wings, forewings, long, 14.50; wide - - - - -	4.00
Wings, hindwings, long, 13.75; wide - - - - -	4.20
Tibia iii, long - - - - -	1.48

Soldier.

Colour.—Head dark chestnut-brown as in imago, the base of rostrum darker, the apex more reddish, a pale median line extending posteriorly from the middle of head to the vertex; anterior half of pronotum same colour as head; antennae, remainder of thorax and tergites of abdomen Dresden-brown; sternites a little lighter, legs much lighter.

Head (Figs. 33 and 34).—With very few setae, short and wide, widest at middle, broadly rounded behind, rostrum moderately stout, shorter than remainder of head, dorsal surface in profile nearly straight. Antennae (Fig. 35) 13-jointed; 1st joint cylindrical, one-fifth wider and more than twice as long as 2nd; 2nd shortest of all, very little shorter than 4th; 3rd markedly longer than 2nd and 4th, very little wider than 2nd; 4th-6th increasing in length progressively, 6th as long as 3rd; 7th and 8th about as long as 6th; 8th-12th decreasing in length; 13th noticeably shorter than 12th.

Thorax.—Pronotum of usual form, the anterior half contrasting in colour with the posterior, anterior margin slightly emarginate, with scanty long setae.

Legs.—Long and rather stout, with few setae on femora; claws and spurs long and slender.

Abdomen.—Short and broad, the tergites excepting the first three much more setaceous than remainder of insect, some setae very long; sternites like posterior tergites, with scattered very long setae.

Measurements.—

	mm.
Total length (variable according to position of head)	3.00 — 3.75
Head, long	1.76 — 1.82
Head, wide	1.08 — 1.14
Pronotum, long, 0.20; wide	0.55
Tibia iii, long	1.08

Soldiers from different colonies vary somewhat in colour and size of head.

Worker.

Colour.—Head ochraceous-buff, with two broad cinnamon-brown bands on each side of the median line, extending from posterior margin of frons towards vertex, the outer pair extending nearly to posterior margin, inner pair shorter and wider; head sutures indistinct; postclypeus and labrum antimony-yellow; antennae and legs cream.

Head.—Short and wide, widest at middle, sides slightly narrowed to the broadly rounded posterior margin, with very few setae. Antennae 14-jointed; 3rd joint nearly always markedly longer than 2nd and 4th; 9th-13th increasing in length progressively; 14th markedly shorter and narrower than 13th. Post-

clypeus small (0.285×0.570), strongly convex and glabrous, median suture very indistinct; anteclypeus about half as long as postclypeus, slightly produced in middle. Labrum similar to that of imago.

Thorax.—Pronotum similar in shape to that of soldier, but of uniform pale colour and with shorter setae.

Legs.—As in soldier.

Abdomen.—Large, widest in middle, broadly rounded behind.

Measurements.—

mm.

Total length	-	-	-	-	-	-	-	-	4.50
Head, to apex of labrum, long	-	-	-	-	-	-	-	-	1.88
Head, to clypeofrontal suture, long	-	-	-	-	-	-	-	-	0.91
Head, wide	-	-	-	-	-	-	-	-	1.36
Pronotum, long, 0.34; wide	-	-	-	-	-	-	-	-	0.74
Tibia iii, long	-	-	-	-	-	-	-	-	1.08

Locality.—South-West Australia: Ludlow (type loc.), Pinjarra, Albany, Lyall Mill (J. Clark), Bunbury (L. J. Newman), Perth (L. J. N. and J.C.); South Australia (from South Australian Museum Collection); Victoria: Kewell (James Hill), and ? from other North-Western localities (Jos. A. Hill, F. E. Wilson, A. J. Campbell, R. Oldfield and D. Long).

Affinities.—The imago does not appear to closely resemble any of the previously known Australian species; all castes, however, are very like several undescribed species of the group to which *E. fumipennis* (Walker) belongs, and the soldiers are certainly conspecific with the specimens referred to by Silvestri (1909) as *E. fumipennis* Froggatt (I have examined some of these specimens from the West Australian Museum). Silvestri uses the same text-figures (221 and 222) for both *E. fumipennis* and *E. fumigatus*, crediting the former species to Froggatt and the latter (correctly) to Brauer in the text and to Froggatt in the explanation of figures. Authentic specimens of *E. fumipennis* (Walker) (type locality "New Holland") are unknown to me, and until a complete series is discovered, and the contained alate imagos found to agree with the unique type, I hesitate to deal with a large number of series the imagos of which have not been found, or, where known, have not been compared with Walker's type. In the case of the proposed new species the alate form has been compared with the above type by Mr. B. Uvarov, through the courtesy of Dr. G. A. K. Marshall, and unhesitatingly referred to a distinct species "the shape of the prothorax being very different in the type (*E. fumipennis*) in that it is scarcely narrowed behind." Froggatt gives a full description of a species which he refers to *E. fumipennis*, but his concluding remarks, indicate doubt in his mind as to the correctness of his determination. I have not seen alate imagos of the proposed new species from South Australia or Victoria, but queens from these localities appear to differ from imagos in the type series only in their paler colour. The Kewell series contains a proportion of

soldiers with entirely dark heads and workers of smaller size than usual.

Biology.—Mr. Clark states that the termitarium is a mound about 2 feet high (rarely up to 4 feet), composed of loose crumbling sandy material on the outside to a depth of from one-half to one inch and of much harder material within. The interior is of more open construction than is the case in the mounds of other species known to him.

Type imago, soldier and worker in the National Museum of Victoria.

EUTERMES GRAVEOLUS, n. sp.

(Plate XXV., Figs. 36-38; Plate XXVI., Figs. 39-42.)

Imago.

Very similar to *E. exitiosus*, n. sp., but smaller; head shorter and generally a little lighter in colour; eyes much larger and more coarsely faceted; head and body more setaceous; pronotum (Fig. 37) longer and wider; wings much shorter, lighter in colour, especially at proximal end, two anteriormost veins distinctly more widely separated at the proximal end.

Measurements.—

	mm.
Length with wings - - - - -	15.00 — 15.75
Length without wings - - - - -	7.50 — 8.00
Head, from base to apex of labrum, long - -	1.50
Head, to clypeofrontal suture, long - - -	1.02
Head, wide - - - - -	1.42
Antennae (Fig. 36; 15-jointed), long - - -	2.00
Eyes, vertically, 0.493; laterally, - - -	0.595
Pronotum, long, 0.85; wide - - - - -	1.42
Wings, forewings, long, 12.50; wide - - -	3.50
Wings, hindwings, long, 12.00; wide - - -	3.75
Tibia iii, long - - - - -	1.70

Included in the long series of alate imagos in the type colony are one imago measuring (with wings) 13.50 long, and a considerable number measuring only 8.00 — 9.00 long. In these the head and body are not much smaller than in normal examples, but the wings are greatly reduced; they are obviously abnormal specimens.

Soldier.

I can find no reliable character by which the soldier of this species can be distinguished from that of *E. exitiosus*. Individuals from different colonies vary in size and colour of head, as in the latter species.

Measurements.—

	mm.
Total length - - - - -	4.00
Head, long - - - - -	1.73
Head, wide - - - - -	0.97
Antennae (Fig. 38; 13-jointed), long - - -	1.53 — 2.10
Tibia iii, long - - - - -	1.14

Worker.

Very similar to that of *E. exitiosus*, but head generally darker and the dark areas more extensive, i.e., extending further laterally and posteriorly. The two species cannot be differentiated on these characters, however.

Measurements.—

	mm.
Total length - - - - -	5.00
Head, to apex of labrum, long - - - - -	1.19
Head, to clypeofrontal suture, long - - - - -	0.97
Head, wide - - - - -	1.36
Pronotum, long, 0.28; wide - - - - -	0.68
Antennae (14-jointed), long - - - - -	1.25
Tibia iii, long - - - - -	1.16

Locality.—Northern Territory: Darwin (type loc.) and district, Bathurst Island (G.F.H.).

Affinities.—A complete nest series from Magnetic Island, N.Q., G.F.H., 14/11/22 (Plate XXVII., Fig. 4), and possibly many series of soldiers and workers from the following localities may be regarded as a local race of the above:—Rockhampton (C. Barrett), Townsville, and vicinity, Malanda (G.F.H.), and Cape River (G. F. Cook). Imagos in the first-mentioned series differ from the typical series in having the head a little larger and darker, wings darker at the base and generally longer, proximal one-third of radial sector closer to radius, numerous short veins between media and radial sector (almost entirely wanting in typical series), wing papillae more numerous; one only has 16-jointed antennae. Similar variations occur in the soldier and worker castes from different colonies to those observed in Northern Territory series. All are from arboreal termitaria. The proposed new species differs from the specimens from Magnetic Island and Townsville, which I have previously described as the imago of *E. yarrabahensis* Mjob. in its smaller size, smaller, lighter and less hairy head, shorter and paler wings, smaller eyes, narrower pronotum and one joint less in antennae.

The group of termites to which *E. fumipennis* (Walker), *E. exitiosus*, n. sp. and *E. graveolus*, n. sp. belong is undoubtedly one of the most difficult to deal with satisfactorily, and it is beyond doubt that several species have been confused by students of Australian termites owing to the apparent absence of distinguishing characters in both soldiers and workers (the castes most frequently captured). In view of the foregoing I have retained for further study about 30 series which I consider to be undeterminable in the absence of alate imagos.

Biology.—The type colony was found in a termitarium (Plate XXVI., Fig. 39), situated 13 feet from the ground in the fork of a small tree in the coastal scrub near Darwin (23/10/13), and was quite typical of many others in the district. The community comprised a queen, situated in a rather large cell in the middle of the mass, an immense number of eggs, soldiers, workers, larvae,

first- and second-form nymphs and alate males and females. The outer wall of the termitarium was very thin and brittle, with a rugose surface, and was composed largely of vegetable matter. The interior was of similar composition, with small crowded cells and passages in the middle and larger ones towards the exterior. "Tubes" or "covered-ways" extended from the ground to the nest, and thence along the larger branches. A somewhat similar nest (Plate XXVI., Fig. 40), occupied by a queen, soldiers and workers only, was found (16/9/16) about 38 miles south-east from Darwin 18 feet from the ground in a *Melaleuca* tree, the trunk of which was probably submerged for several months during and after the wet season. This termitarium, like many others in the district, had been used by kingfishers (*Halcyon macleayi*) as a nesting place. Termitaria of this, or a closely allied species, were found on Bathurst Island in mangrove trees the trunks of which were almost continually in tidal water. Soldiers and workers are often found on the ground under fallen logs and vegetable debris, and in "tubes" on the trunks of trees which contain no termitarium; it appears, therefore, that new colonies live in the soil for some time before constructing the typical arboreal nests. This species, like the North Queensland form here, provisionally regarded as a local race of it, never constructs termitaria upon the surface of the ground. "Tubes," under cover of which these termites pass backward and forward between the soil and the nest, are illustrated in Plate XXVI., Figs. 41 and 42. I know of no instance of damage having been done by this species to trees or buildings.

Type imago, soldier and worker in the National Museum of Victoria.

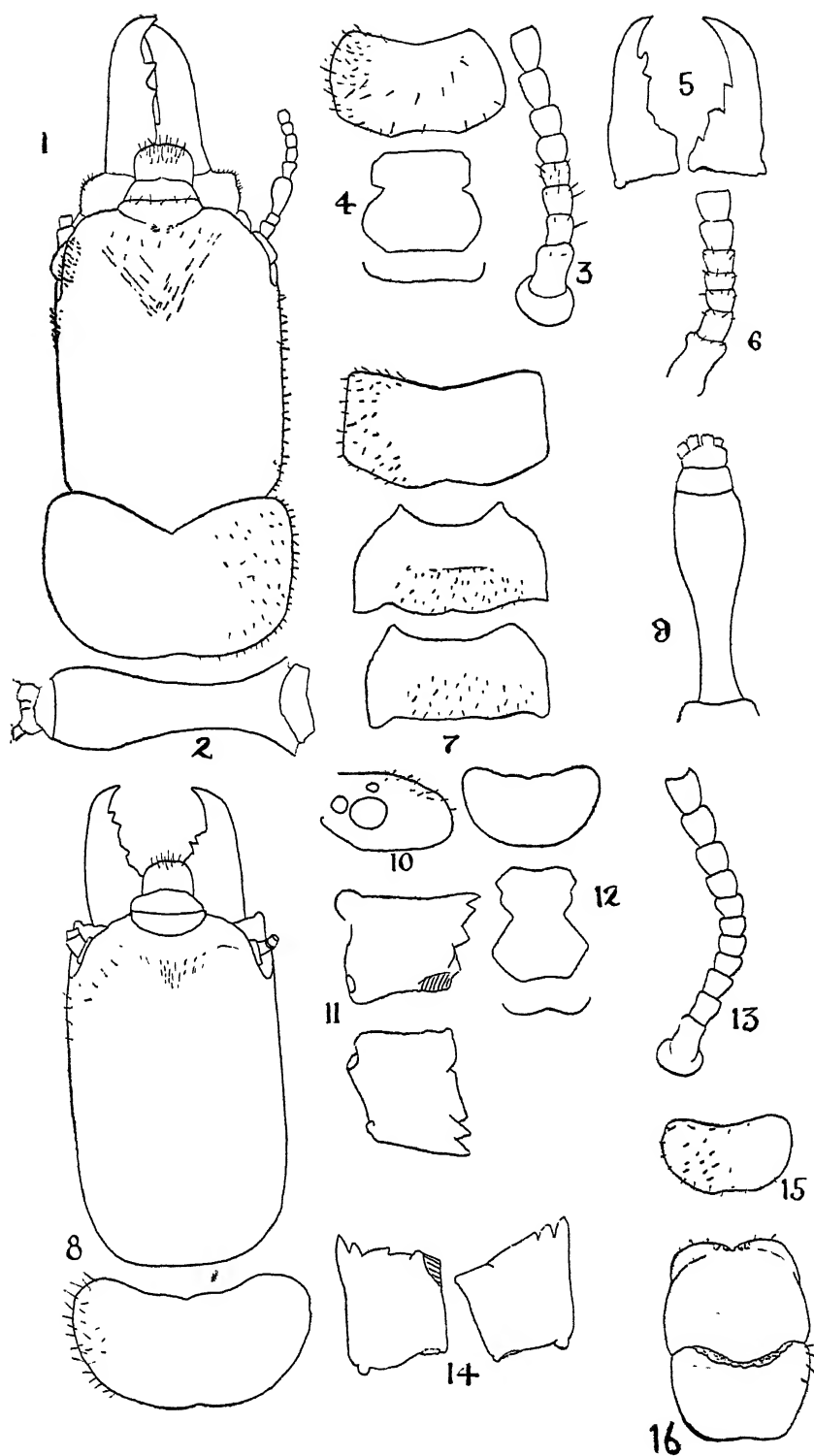
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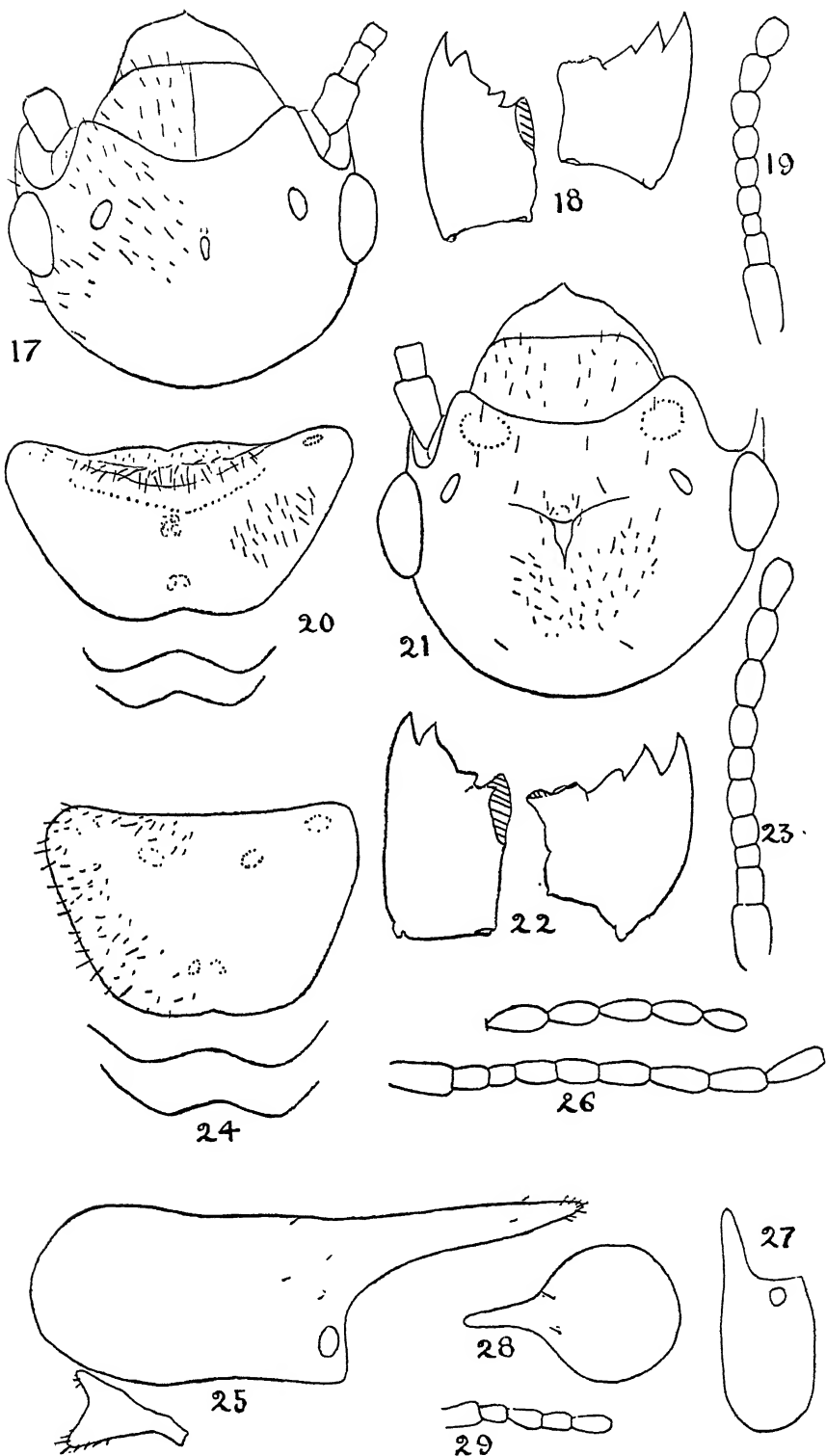
- HOLMGREN, NILS.—Termitenstudien. *Kungl. sv. vet. Akad.*, Bd. 44, No. 3, 1909.
 HILL, G. F.—*Proc. Linn. Soc. N.S.W.*, xlv. (4), 1921.

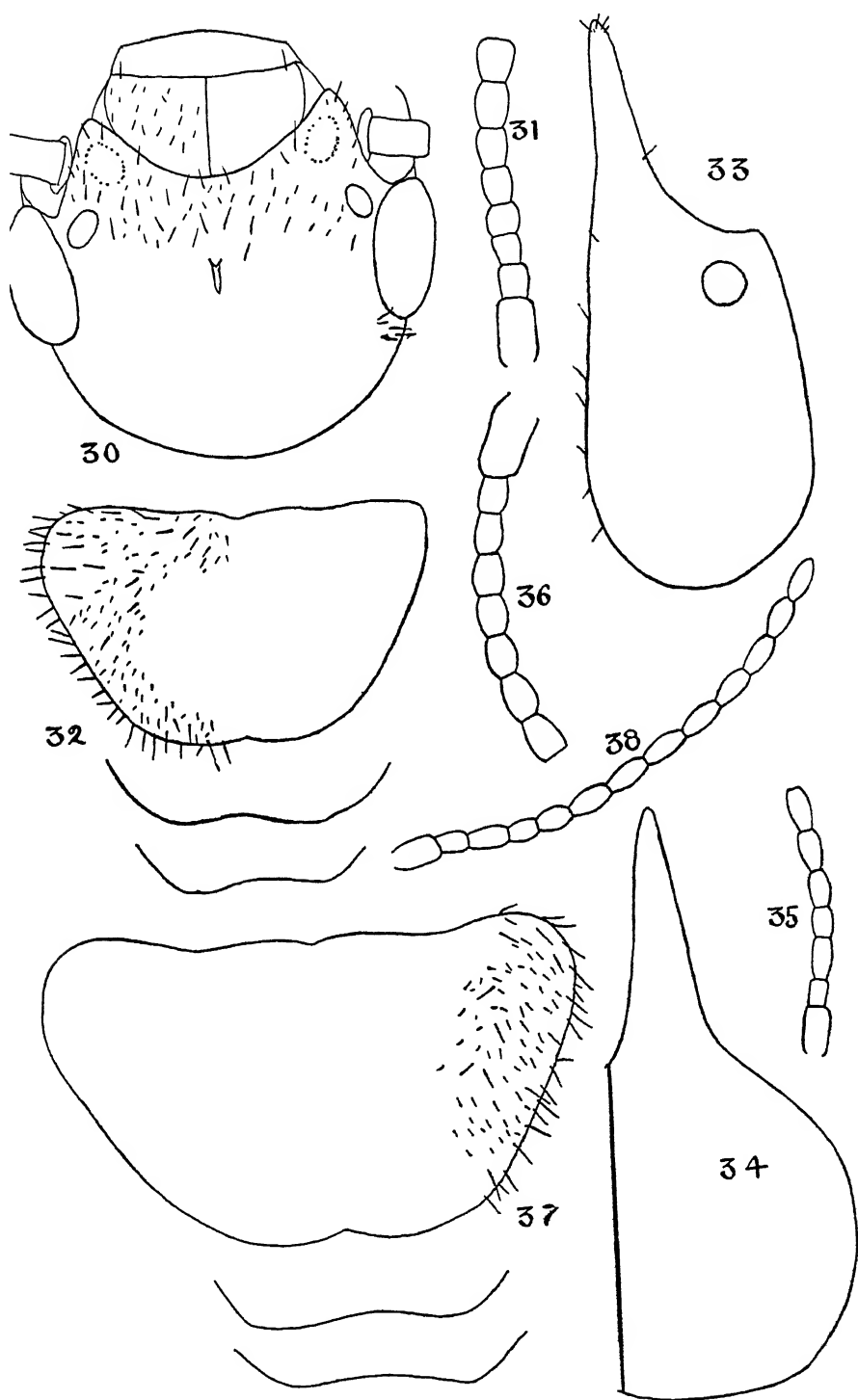
EXPLANATION OF PLATES.

PLATE XXIII.

- Fig. 1.—*Calotermes oldfieldi*, n. sp. Soldier: Head and pronotum.
 Fig. 2.—*Calotermes oldfieldi*. Soldier: Gula.
 Fig. 3.—*Calotermes obscurus* (Walk.). Imago: Antenna.
 Fig. 4.—*Calotermes obscurus*. Imago: Pronotum, mesonotum and posterior margin of metanotum.
 Fig. 5.—*Calotermes obscurus*. Soldier: Mandible.
 Fig. 6.—*Calotermes obscurus*. Soldier: Antenna.
 Fig. 7.—*Calotermes obscurus*. Soldier: Pro-, meso- and metanotum.
 Fig. 8.—*Calotermes iridipennis* Frogg. Soldier: Head and pronotum.









39



40



41



42

- Fig. 9.—*Calotermes iridipennis*. Soldier: Gula.
 Fig. 10.—*Calotermes claripennis*, n. sp. Imago: Head from the side.
 Fig. 11.—*Calotermes claripennis*. Imago: Mandibles.
 Fig. 12.—*Calotermes claripennis*. Imago: Pronotum, mesonotum and posterior margin of metanotum.
 Fig. 13.—*Calotermes arcanus*, n. sp. Imago: Antenna.
 Fig. 14.—*Calotermes arcanus*. Imago: Mandibles.
 Fig. 15.—*Calotermes arcanus*. Imago: Pronotum.
 Fig. 16.—*Calotermes secundus*, n. sp. Soldier: Head and pronotum from above.

PLATE XXIV.

- Fig. 17.—*Eutermes apiocephalus* Silv. Imago: Head.
 Fig. 18.—*Eutermes apiocephalus*. Imago: Mandibles.
 Fig. 19.—*Eutermes apiocephalus*. Imago: Antenna.
 Fig. 20.—*Eutermes apiocephalus*. Imago: Pronotum and posterior margin of meso- and metanotum.
 Fig. 21.—*Eutermes westraliensis* Hill. Imago: Head.
 Fig. 22.—*Eutermes westraliensis*. Imago: Mandibles.
 Fig. 23.—*Eutermes westraliensis*. Imago: Antenna.
 Fig. 24.—*Eutermes westraliensis*. Imago: Pronotum and posterior margin of meso- and metanotum.
 Fig. 25.—*Eutermes peracutus*, n. sp. Soldier: Head.
 Fig. 26.—*Eutermes peracutus*. Soldier: Antenna.
 Fig. 27.—*Eutermes centraliensis*, n. sp. Soldier: Head in profile.
 Fig. 28.—*Eutermes centraliensis*. Soldier: Head from above.
 Fig. 29.—*Eutermes centraliensis*. Soldier: Antenna.

PLATE XXV.

- Fig. 30.—*Eutermes exitiosus*, n. sp. Imago: Head.
 Fig. 31.—*Eutermes exitiosus*. Imago: Antenna.
 Fig. 32.—*Eutermes exitiosus*. Imago: Pronotum and posterior margin of meso- and metanotum.
 Fig. 33.—*Eutermes exitiosus*. Soldier: Head in profile.
 Fig. 34.—*Eutermes exitiosus*. Soldier: Head from above.
 Fig. 35.—*Eutermes exitiosus*. Soldier: Antenna.
 Fig. 36.—*Eutermes graveolus*, n. sp. Imago: Antenna.
 Fig. 37.—*Eutermes graveolus*. Imago: Pronotum and posterior margin of meso- and metanotum.
 Fig. 38.—*Eutermes graveolus*. Soldier: Antenna.

PLATE XXVI.

- Fig. 39.—*Eutermes graveolus*, n. sp. Termitarium (type colony).
 Fig. 40.—*Eutermes graveolus*. Termitarium in Melaleuca in swamp 38 miles from Darwin.
 Fig. 41.—*Eutermes graveolus*, var. Termitarium in Eucalypt tree, Magnetic Is., N.Q.
 Fig. 42.—*Eutermes graveolus*, var. "Tubes" on trunk of Eucalypt, Magnetic Is., N.Q.

ART. XIV.—*Contact Metamorphism in the Bulla Area and
Some Factors in Differentiation of the Granodiorite
of Bulla, Victoria.*

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(With Plate XXVII.)

[Read 11th December, 1924.]

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 - C. Relation of chemical composition to mineral content.
 - (i.) Cordierite-Biotite-Quartz and Sericite-Biotite-Quartz Hornfels, Quartzite.
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4. SUMMARY AND CONCLUSIONS.

1—General Geology.

The Geology and Physiography of the Bulla area have been described by Mr. A. V. G. James.¹

The oldest rocks outcropping are Palaeozoic mudstones, with minor sandstones and conglomerates. These may include rocks of both Upper Ordovician and Silurian age. Lithologically there is no well defined difference between the two series, and both have probably been derived from the same land mass. Similar rock types are derived from both series by contact metamorphism. The beds dip steeply to the east and strike generally about N. 15°E. (magnetic bearing). Intrusive into these sediments is a mass of granodiorite, presumably Lower Devonian in age. This mass extends beneath later basalt flows north-eastward through Broadmeadows to Somerton and Craigieburn. The intrusion took place without contortion of the sediments, and caused the formation of contact rocks, which form the subject of the first part of this paper. The granodiorite is much decomposed everywhere on the surface exposures, although fairly fresh in the bed of Deep Creek. Blocks of the fresh rock have been blasted out on the western bank of the stream about half a mile south of the school.

Cainozoic sediments are found in various parts of the area, and much of the area has been covered by Newer Basalt.

Deep Creek has cut a deep trench through the younger rocks, and has exposed the Palaeozoic rocks and rocks of the contact zone. These latter are best studied along the northern side of the meander, a mile south of Bulla, as here the greatest variety of rock types is found, and the strike of the beds runs nearly at right angles to the boundary of the granodiorite. Poorer sections are seen on the northern bank of the east-west sweep of the river, about half a mile north of Bulla, and on the hillside opposite the school.

The locations of features mentioned in this paper are illustrated on a map enlarged from portion of James's map to which minor alterations have been made. The quartzite (Q) and sericite-rich band (S) have been added. From the general strike of the rocks, conglomerates C_3 and C_4 of James's map are the same bed, and the placing of C_3 directly south of C_4 is incorrect. The shape and location of the Hanging Valley are incorrect, and the conglomerate C_4 does not pass northward under basalt, but may be traced to within two chains of the contact of the granodiorite, against which it abuts, as shown in the accompanying map. James considers that the rocks west of C_1 (seen on Jackson's Creek, south-west of the Bulla meander) are Upper Ordovician. There is a band of white sandstone here at the same distance east of C_1 as the quartzite is east of C_3 - C_4 on the Bulla meander, and the thicknesses of sandstone and quartzite respectively are approxi-

1.—A. V. G. James. Proc. Roy. Soc. Victoria, Vol. XXXII. (N.E.), Pt. II, 1920.

mately the same. There is reason to believe that the quartzite is the northern prolongation of the sandstone, and therefore that C_3 - C_4 is the northern prolongation of C_1 . On these grounds the Palaeozoic rocks west of C_3 - C_4 are marked on the map as Upper Ordovician. There appears to be a thinning out of the conglomerate northwards, and this may account for the absence in the Bulla meander area of the equivalent of C_1 , on James's map, which appears only as a thin band on the Jackson's Creek section.

2—Contact Metamorphism.

A. General Character of Contact Zone.

The contact zone is variable in width, but on the average extends about a quarter of a mile from the actual contact. The change to unaltered rock is rather abrupt. The mudstones grade into an indurated, darker, uncleaved spotted rock, which in turn grades into the characteristic dark blue dense hornfels of the inner zones. The quartzites, of which there are two bands just east of the mouth of the Hanging Valley, show induration at a considerable distance from the contact, where they are grey in colour, and at the contact zone they become very massive and pink in colour. The sericite-rich bands, the largest of which is that shown in the map as S, do not change much in physical character by metamorphism.

B. Rock types found within the Contact Zone.

(i.) *Cordierite-Biotite-Quartz Hornfels*.—These form the bulk of the altered rocks. They vary according to the relative amounts of the three main constituents. Types rich in cordierite macroscopically appear fine-grained, and have a resinous lustre; types rich in quartz are coarser in grain. The former are abundant on the neck of the meander, the latter occur close to the conglomerate. The typical hornfels is intermediate between the two extremes, and is well represented along the cliff west of the mouth of the Hanging Valley.

(a) Original sediment from which the hornfels has been derived. [1630].²—This consists of quartz grains set in a fine matrix of sericite, chlorite and iron ore. There are occasional grains of apatite and zircon, prisms of tourmaline and needles of rutile.

(b) Transitional types.—The least altered rock [1631] shows a trace of clotting of the minerals seen in the unaltered rock, but in addition secondary biotite appears. This is a quartz-rich type collected from a bed adjacent to the quartzite on the southern bank of the southern side of the meander.

Transitional types of rock, which on complete recrystallization give cordierite-rich types, are found further down-stream on the

2.—Numbers in brackets refer to rock-sections in the collection of the Geological Department, University of Melbourne.

northern bank of the next meander. [1632, 1633, 1634.] Clotting is well developed in these. The clots are green in colour, and surrounded by lighter areas. In the lighter areas biotite is developed, the various degrees of development being seen progressively in the three sections. In the most altered type [1634] its development is almost complete. Accessory minerals are similar to those of the unaltered rocks. This type of clotting in which no new minerals are developed has been referred to by other writers,^s and has been put down to solution effects. It may be readjustment of phases in response to higher temperature conditions.

(c) Recrystallized types.—Cordierite-rich types [1635 and 1640] show large anhedral patches of cordierite surrounded by a fine-grained mass of biotite flakes, quartz and cordierite grains. These large cordierite patches are full of inclusions of very small flakes of biotite and accessory minerals. By their relation to the ground mass they are clearly derived from the green clots, and they show no parallelism of arrangement. Sections [1634 and 1635] are from rocks only 15 yards apart, so that it would appear that once started, the development of cordierite is rapid.

The typical hornfels [1636], collected from the southern bank of the northern side of the main meander, shows less cordierite, with more quartz and biotite. The cordierite is clearer and the other minerals are better developed. The texture is granoblastic, but cordierite tends to enclose rounded grains of recrystallized quartz. There is a little secondary tourmaline.

(d) Inner Contact Zone types.—Rocks from the inner zone [1637-1639 and 1642-1644] are similar to the recrystallized types, but contain in addition grains of alkali feldspar and flakes of muscovite. A siliceous type [1645], in which original quartz grains are left after recrystallization, has a grain of plagioclase feldspar in it. This may be an original grain in the sedimentary rock. The actual contact hornfels [1639] possesses numerous grains of alkali feldspar, and flakes of muscovite, while the cordierite is partially sericitized. Fully recrystallized hornfels lacking feldspar and muscovite may be obtained at a distance away from the contact, so that these minerals appear to be characteristic of any line of strike within the inner contact zone, as all the collections were made at different points along the contact and as close to it as possible; therefore, it seems probable that these minerals are secondary.

(ii.) *Sericite-Biotite-Quartz Hornfels*.—These are grey in colour and have not the hardness of the cordierite-biotite-quartz hornfels. A specimen from the wide band previously mentioned, in thin section [1646] is seen to consist of round quartz grains set in a mass of more or less recrystallized sericite. The similarity of this sericite matrix to poikiloblastic cordierite of the cordierite hornfels might indicate that this type is an alteration product of

3.—C. E. Tilley: "Contact Metamorphism in the Comrie Area." *Quart Journ. Geol. Soc.*, Vol. LXXX., Part I, 1924.

the cordierite hornfels, but the junction with typical hornfels of the latter on either side along the strike does not favour this view; moreover the biotite shows no trace of alteration.

(iii.) *Quartzites*.—Two sections [1647 and 1648] have been cut from the bands shown on the map as Q, at positions on the southern and northern sides of the meander respectively. These bands are lost under the basalt immediately south of the meander, but as indicated earlier their unaltered equivalents are found as white sandstones in the Jackson's Creek section. They are almost pure quartz rocks, but contain a little iron ore and sericite.

In the grey quartzite [1647] from the more southern exposure, the ore mineral is magnetite, while in the pink rock [1648] of the contact zone it is hematite to which the colour of the whole rock is due. The sericite is recrystallized in the latter. Lines of bubbles and inclusions pass through the rock irrespective of quartz grains. There is no siliceous binding material, and strength is evidently due to the interlocking of grains.

(iv.) *Amphibole Hornfels*.—These are rare, and appear to occur only in one or two beds of pale green, highly siliceous hornfels close to the altered conglomerate, and in parts of the matrix of the conglomerate itself. In the former occurrence [1649], the amphibole is a green variety, occurring with biotite in the ground mass surrounding unaltered quartz grains. In the matrix of the conglomerate [1650] the amphibole is in the form of pale green needles having an extinction angle of about 16° . It is, therefore, probably actinolite. Part of the section shows a pebble of quartz porphyry. Most of the pebbles of the conglomerate, however, are of quartzite or chert.

(v.) *Cordierite-Biotite-Quartz Hornfels modified by the introduction of alkaline material*.—This alkaline material threads its way irregularly through the hornfels as a vein, and on each side of the vein the hornfels is seen to have large crystal surfaces, typical of feldspar, within it. The first example [1653-1657] was found on a boulder embedded in the sand at the foot of the mouth of the Hanging Valley, while, later, a similar type of rock was found *in situ* directly above the first example on the top of the cliff. The two occurrences may in reality be the same, but in the latter case the impregnation in the hornfels is more widespread.

The vein itself [1653] consists of acid feldspars, probably orthoclase and oligoclase, which include small rectangular flakes of biotite, magnetite aggregates pseudomorphous after biotite, grains of an isotropic serpentinous mineral, plates of tourmaline enclosing rounded quartz grains, and quartz grains of various sizes. Muscovite flakes are also abundant, and are quite distinct from sericite derived from the feldspars by normal weathering processes.

This vein junctions irregularly with altered hornfels [1654 and 1655], which is full of feldspar acting as a base for biotite, quartz, muscovite, and sericitized and serpentinized cordierite. Tourmaline occurs in plates, perforated by other minerals, and, like the feldspar, is clearly introduced.

Further away from the vein [1656] cordierite, only partially sericitized, appears, while the hornfels only slightly affected [1657] is strikingly similar to the contact zone hornfels [1639]. Thus it would appear that this vein of alkaline minerals represents an intense form of the introduction of feldspar and muscovite characteristic of the inner contact zone hornfels. The minerals were probably deposited from a very fluid, highly aqueous differentiation product of the magma, which made its way by reaction with the hornfels rather than by forcing its passage. This reaction phenomenon will be discussed later.

(vi.) *Lime-silicate Hornfels*.—These occur as white or cream-coloured lenticles in the cordierite-biotite-quartz hornfels between the quartzite and conglomerate on the cliff west of the mouth of the Hanging Valley. Their unaltered equivalents have not been found, but are probably calcareous concretions. They are banded on their exterior, the bands being distinct from each other, while the outermost band, although somewhat resembling the ordinary hornfels, is distinct and the junction is abrupt.

Generally speaking, the mineral associations are similar. The outer bands [1661, 1664, 1669] are characterised by actinolite, which is present as needles often arranged in stellate fashion. Quartz is always present, and in one case [1661] there is a fine-grained mass of colourless mineral with a refractive index between that of quartz and actinolite, and showing low polarization colours. This mass contains occasional twinned basic plagioclases, and probably consists of this mineral itself. Pyrrhotite is an abundant mineral of the outer bands of some of the lenticles [1669]. This mineral is characteristic of all the altered rocks at Bulla, and may be due to the combination of sulphur bearing salts with iron during metamorphism.

In the next bands diopside appears, usually first as a fine-grained mass and later as crystals. Plagioclase may remain, but amphibole disappears. A few crystals of zoisite occur [1661], and also a cloudy mineral having a refractive index intermediate between quartz and diopside, and birefringence comparable with that of diopside. The sections of the interior of two lenticles [1662 and 1663] consist of diopside, quartz and this cloudy mineral. Other lenticles which probably had less free quartz originally [1664, 1665, 1666, 1667] consist of small diopside grains set in a mass of mineral which makes up much of the rock. This mineral is divided into what appears to be prismatic crystals, oriented more or less in one direction. The following optical properties have been determined:—

- (i.) Straight extinction along a cleavage, seen in crystals exhibiting the higher polarization colours.
- (ii.) Biaxial; positive; elongation negative.
- (iii.) Birefringence comparable with diopside.
- (iv.) Medium refractive index, but less than diopside.

(v.) Oriented with acute bisectrix perpendicular to the cleavage plane.

(vi.) Colourless; non pleochroic.

The mineral is evidently orthorhombic and prehnite, $\text{H}_2\text{Ca}_2\text{Al}_2(\text{SiO}_4)_3$, corresponds optically. The typical rosette structure of prehnite is absent, however, although in one occurrence [1668] the mineral occurs in leafy aggregates.

Calcite is present in the interior of the basic lenticles, and in one a vein of pure recrystallized calcite has been observed.

The cloudy mineral of the other sections [1662 and 1663] may also be prehnite, but optical properties cannot be easily determined.

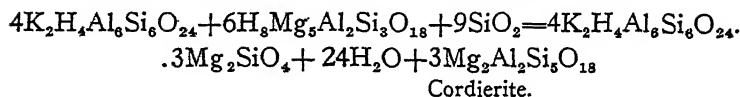
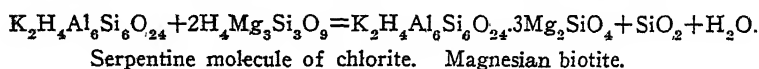
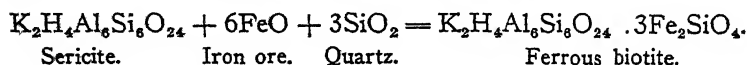
C. Relation of Chemical Composition to Mineral Content.

(i.) *Cordierite - Biotite - Quartz and Sericite - Biotite - Quartz Hornfels.*—No analyses of these types from Bulla have been made, but the first-named is probably typical of its class, and the following analysis used by Tilley⁴ would represent approximately the composition:—

SiO_2	-	-	59.83
Al_2O_3	-	-	17.47
Fe_2O_3	-	-	4.09
FeO	-	-	3.93
MgO	-	-	3.70
CaO	-	-	0.49
Na_2O	-	-	1.08
K_2O	-	-	4.42
H_2O	-	-	3.80
TiO_2	-	-	0.93
P_2O_5	-	-	0.18
SO_3	-	-	0.13

100.05

Tilley gives certain theoretical equations for the formation of biotite and cordierite from sericite and chlorite.



4.—Op. supra cit.

If biotite and cordierite were minerals of fixed composition, then, unless the relative amounts of sericite and cordierite in the original sediments remained constant, additional minerals would have to appear. Among the Bulla contact rocks of this type, the minerals cordierite, biotite, quartz, only appear in the perfectly recrystallized rock. The variation in original chemical composition of the sediment is taken up by isomorphous mixtures in the hornfels minerals. Thus MgO and FeO vary in biotite and cordierite; Al_2O_3 and Fe_2O_3 in biotite; and the proportion of salic to femic constituents in the biotite. If chlorite rises in proportion to sericite, alkali will be lower, and hence cordierite will rise in proportion to biotite.

If sericite rises in proportion to chlorite, cordierite diminishes till finally it disappears, and, with sericite the dominant constituent of the sedimentary rock, sericite-biotite-quartz hornfels results. The elimination of sericite and chlorite gives first the quartz rich type and in the extreme case quartzite.

(ii.) *Amphibole Hornfels and Lime-silicate Hornfels.*—The amphibole of the former may be due to the presence of a small amount of lime in the original sediment.

In the latter, the various bands indicate an increase in lime towards the centre of the lenticle, with a relative decrease of alumina and magnesia. Amphibole and plagioclase take the place of biotite and cordierite in the outermost band, amphibole then disappears, and diopside with a higher CaO: MgO ratio appears. Finally prehnite (?) and recrystallized calcite are found in the centre of the lenticle.

D. Factors Producing Metamorphism.

Compared with the effects of certain other contact alterations in Victoria, the metamorphism at Bulla seems to be excessive when the size of the granodiorite intrusion is considered.

Pneumatolysis does not appear to have played a very important part in the process of recrystallisation, as minerals associated with pneumatolytic action are rare; tourmaline is, in fact, the only one present, and then not in great quantity. Furthermore, the effects of impregnation of hornfels with alkaline solutions containing tourmaline, and doubtless associated with the last stages of crystallization of the magma, occurred after the fundamental recrystallization which formed the hornfels, and have destroyed this fundamental recrystallization by decomposing biotite and cordierite, rather than perfecting their development.

It would seem that the nature of the sediments themselves plays an important part in effecting the metamorphism. At Bulla the sediments consist largely of hydrated minerals and minerals having diverse composition, viz., sericite and chlorite. The water of these sediments would have its solvent and chemical powers considerably increased by heat, but solution has acted only within a limited range, as variation of texture and composition of indivi-

dual strata are sharply preserved in the recrystallized rock. [1641.]

Goldschmidt⁵ considers that dry reaction of minerals in the solid state is the main process in metamorphism, in the case of the rocks of Christiania, Norway. This process is probably important at Bulla, and, just as in silicate melts the melting points of the individual components are lowered by the presence of other components, so with systems reacting in the solid state, the ease with which new minerals form, is increased by the heterogeneity of the reacting mass. The intimate nature of the mixture of sericite and chlorite would also help in furthering reaction.

Probably the best suite of contact rocks in Victoria occurs at Mt. Tarrengower, Maldon, and here the hornfels are similar to (though even better developed than) the Bulla hornfels. At Trawool are contact rocks which show cordierite-biotite-quartz [1651] and sericite-quartz [1652] hornfels alternating. The effects appear to have been greater in intensity and distribution in the former type than in the latter.

It is probable that active invasion of the wall rocks by an intrusive magma will have stopped before complete solidification, so that after this stoppage the residual heat of the magma is disseminated through the same sediments instead of repeatedly fresh ones, thereby allowing more perfect recrystallisation in these sediments. For certain reasons, which will be given later, the period between the stoppage of the physical expansion and the final consolidation of the Bulla granodiorite appears to have been considerable, and this may have played some considerable part in effecting the metamorphic changes.

The temperature of crystallization of a granite magma is probably comparatively low, perhaps between 400°C. and 500°C. This low temperature would favour the formation of hydrated minerals such as biotite and prehnite, and amphiboles, in the contact rocks.

3.—Processes in the Differentiation of the Granodiorite.

A. Granodiorite.

There is always considerable difficulty in obtaining equigranular granodiorite free from numerous dark aggregates which are disseminated through it. It has been described by James, and his description will suffice. It might be added that the plagioclase feldspars have a composition approximating to $Ab_{80}An_{20}$ in the central zones, but grade to acid oligoclase in the outer zones. The other minerals present are quartz, orthoclase, biotite which is usually more or less chloritized, muscovite, accessory minerals, sericite, calcite and kaolin derived from the feldspars. Occasionally pale green aggregates, which do not appear to have any relation to the other minerals, are present. [1682 and 1687.]

5.—V. M. Goldschmidt: "Die Kontaktmetamorphose im Kristianlagebiet."

B. Cognate Xenoliths.

These are numerous and of varying size. They are distinguished from accidental xenoliths by their relatively coarse and equigranular texture, and grain size is the only respect in which they differ greatly from the granodiorite. One which in appearance is more basic than the average [1673] shows quartz to be abundant and enclosing smaller crystals of altered plagioclase and biotite flakes. It is doubtful whether the term "basic segregation" can be applied to this specimen.

C. Accidental Xenoliths.

(i.) *Recognizable Hornfels which has undergone slight re-action.*—These rocks have been collected from comparatively fresh boulders of granodiorite in the bed of Deep Creek. They are by no means as common as cognate xenoliths. In thin section [1670 and 1671], they are seen to consist of the usual cordierite-biotite-quartz assemblage, with numerous grains of plagioclase feldspar of composition about $Ab_{70}An_{30}$. In one case [1670] there is a single twin of orthoclase enclosing the hornfels minerals, and in the hand specimen such crystals are occasionally seen, exhibiting their faces in a manner similar to feldspars of the hornfels impregnated with alkaline solutions, discussed previously. Magnetite is abundant in this rock, and appears to have imparted to some of the cordierite intergrown with it a pale yellow colour and faint pleochroism.

(ii.) *Xenoliths coarser in grain than recognizable hornfels.*—These are rare. They were at first sight mistaken for fine-grained basic cognate xenoliths, but in section [1672] the hornfels assemblage is seen to be present and also oligoclase of composition $Ab_{70}An_{30}$, which forms more than a quarter of the area of the whole section. All the minerals are coarser in grain than the minerals of hornfels and the cordierite has been cleared of its inclusions and exhibits definite cleavage. The size of such xenoliths as have been found does not exceed three inches in length.

(iii.) *Foliated xenoliths.*—These are usually only up to an inch in length. They contain abundant biotite flakes arranged in a more or less parallel fashion, which gives a foliated appearance to the rock. In section they show interesting mineral assemblages. [1674-1678.] When cut parallel to the foliation plane biotite appears as rich red-brown plates. [1674.] In addition, within this section are unzoned plagioclases which appear, however, to vary slightly among themselves in composition. They are more acid than the plagioclase cores of the granodiorite, and have compositions in the neighbourhood of $Ab_{65}An_{35}$. Magnetite is abundant in areas rich in biotite. Cordierite is very abundant as large areas of colourless mineral possessing indistinct cleavage and brilliant yellow pleochroic haloes round minute colourless, highly refracting

inclusions. The cordierite is clouded with minute, rod-like inclusions of higher refractive index than their host, and these are without doubt sillimanite. There are also small bottle-green isotropic grains and aggregates having a very high refractive index, and often resembling cubic forms. These are spinels.

Another section [1675] shows pleochroic haloes, sillimanite and spinel excellently developed. Part of the section has the simple cordierite-biotite-plagioclase-quartz assemblage similar to that of type (ii.). Leafy aggregates of muscovite are abundant, and intergrown with these is a pale-green biotite of similar habit, which sometimes is altered to chlorite of a similar colour. This biotite occurs in several sections to be described, and from examination of several basal sections is seen to have a low axial angle. It is weakly pleochroic. Brownish biotite often grades into greenish biotite, being in optical continuity with it. These leafy micas appear to crystallize from pale green aggregates of finer grain. These aggregates often contain "ghosts" of brown biotite merging into them. They also contain numerous olive green pleochroic haloes and exhibit, as a mass, cleavage lines, which are continuous with cleavage lines of adjacent cordierite. From the occurrence of the green aggregates it seems certain that they are derived from cordierite. They are identical with the isolated areas of pale micas seen in the granodiorite itself.

The foliated structure is not always well-defined in the hand specimen, especially in the smaller examples. There is really a transition into the small disseminated aggregates which are described in the next section; a transition type [1676] is seen to have similar mineral associations. Sillimanite is especially well-developed. The brown biotite is particularly clear and differs from the biotite of the granodiorite, which is rather dull in comparison. Part of this section is of the adjacent granodiorite, and a beautiful example of simply-twinning zoned plagioclase, ranging from andesine well towards albite, is present. The characters of the other sections [1677 and 1678] are similar. The spinels of [1678] are grouped in large aggregates.

(iv.) *Small dark aggregates disseminated throughout the granodiorite.*—These seldom exceed $\frac{3}{8}$ inch in diameter, and are usually smaller. They form an important constituent of the granodiorite as a whole, and it is almost impossible to select a piece of granodiorite which lacks them. In section [1679, 1680, 1681] they are seen to have similar characteristics to the foliated xenoliths, but the alteration of cordierite has usually proceeded further. The phenomenon of green and brown biotite in optical continuity is particularly well developed [1680], while in one [1681] a large garnet is present. The interstitial cracks of this garnet are filled with green biotite, which is rather darker in colour and more strongly pleochroic than usual.

(v.) *Cordierite Crystals.*—These were at first mistaken for hypersthene or hornblende. They occur as fragments up to half

an inch in length, possessing a dark green colour, often rectangular outlines, and one good cleavage. In thin section [1683-1684-1685] this cleavage (parallel to 010) is seen to be perfectly developed, while another cleavage at right angles to it is seen. Pleochroic haloes are well developed, though not very numerous. The pale green micaceous mixture is always abundant, and in addition large portions of the crystals have often changed to serpentine. Traces of this serpentine are also found in the other accidental xenoliths, and it is to this mineral and the green mica that the cordierite crystals, partly altered, owe their colour, and their hornblendic or hypersthentic appearance.

D. Explanation of the Accidental Xenoliths by the Reaction Principle.

This principle and its relation to petrogenesis have been outlined and applied by N. L. Bowen.⁶ Briefly, it may be stated thus:—Earlier minerals crystallizing out react successively, as the temperature falls, into minerals of lower temperature formation. A typical reaction in which the change over is continuous, is the plagioclase feldspars system. A typical discontinuous series is represented by the series Olivine-Pyroxene-Amphibole-Biotite. In simple igneous rock-magmas these two combine at lower temperatures, and the later members of the combined series are Orthoclase, Muscovite and Quartz. Generally speaking, in both continuous and discontinuous series, if an early member is added to a liquid in equilibrium with a later member, the early member is made over by reaction with the late member. If a late member is added to a liquid in equilibrium with an early member, the late member is melted into the liquid, and the early member crystallizes to supply the heat for melting. Sedimentary rocks are fortuitous in composition, and their minerals do not fit into igneous rock series, but up to a certain extent they may by reaction affect the composition of the phases of an igneous rock which includes fragments of them, without changing their actual phases. Acid magmas in the form of batholiths are probably never superheated, and the great amount of heat extracted in first of all heating the wall rock and inclusions up to the temperature of the magma itself, forbids, to any great extent, the reaction between magma and inclusions.

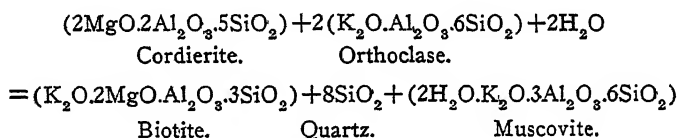
This principle may now be applied to the xenoliths of the Bulla granodiorite. The cognate xenoliths probably represent the remains of the magma at some previous time, and it is doubtful if the magma was much, if at all, more basic before the absorption of the present accidental xenoliths than it is now. The plagioclase crystallizing out was probably somewhat more acid than $Ab_{60}An_{40}$, as the cores of the plagioclase of the granodiorite

6.—N. L. Bowen: "Reaction Principle in Petrogenesis." *Journ. Geol.*, Vol. XXX., No. 3, 1922. *Idem*, "The Behaviour of Inclusions in Igneous Magmas." *Ibid.*, Vol. XXX., No. 4, Supplement, 1922.

have this composition, while the plagioclase within the accidental xenoliths is considerably more acid.

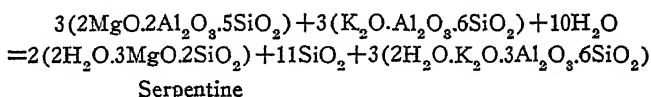
The xenoliths of hornfels are probably broken up by mechanical means as they enter the magma, reaction thereby being facilitated. The minerals of the hornfels are quartz, biotite and cordierite. The first two are members of the general igneous rock series, but the last is foreign to this series. Quartz, being the latest member of the reaction series, is melted, while plagioclase more acid than $\text{Ab}_{60}\text{An}_{40}$ crystallizes, either within the xenoliths, which tend to disintegrate by the removal of quartz, or upon the plagioclase crystals of the granodiorite already formed. The removal of quartz allows the other constituents of the reacting hornfels to come together more in contact with each other, and these unite to form larger crystals, and in extreme cases produce, with cordierite-rich hornfels, almost pure, more or less idiomorphic cordierite crystals.

Cordierite is unstable in contact with the liquid of the magma, and therefore decomposes into muscovite and pale green biotite, the latter being very poor in ferric iron, which indicates that the cordierite was also very poor in this constituent. The decomposition may be represented by the following equation—

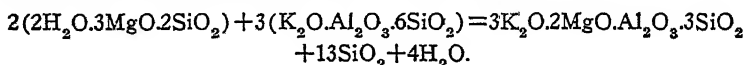


The alkaline constituent of the liquid is represented for convenience by the orthoclase molecule. The biotite, in which potash and hydrogen may be isomorphous, is represented as having all potash, which would not be so actually, and likewise ferrous-iron of the biotite and cordierite has been omitted, and the pure magnesian molecules used.

Serpentine may result from cordierite from a reaction of the following nature—



On complete disintegration and mixing with the magma liquid, this serpentine would be made over to biotite.

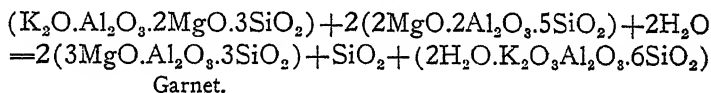


The brilliant red-brown biotite of the xenoliths and occasional included flakes in the cordierite crystals are recrystallized flakes from the original hornfels. This mineral appears also to be adjusting its composition to that of the pale green variety, and

hence arise the lighter edges on the brown flakes and the biotite "ghosts" within the pale green aggregates.

Cordierite is a metasilicate while biotite and muscovite are orthosilicates, hence, as shown by the equations, quartz is liberated; furthermore by crystallization reaction this quartz is melted and removed, along with the quartz of the original hornfels, so that the xenoliths become more basic. We cannot picture the general temperature of a granitic magma as being anywhere near as high as the melting point of cordierite, even though the latter be reduced by the presence of other minerals, so that this mineral cannot melt within the xenoliths, but the temperature being still high and maintained in all probability for a great length of time, reaction can take place. Cordierite decomposes into sillimanite and spinel with a separation of quartz. The quartz is melted off, and the reaction tends to proceed till cooling of the whole mass prevents further reaction, or the cordierite decomposes entirely into micas. As soon as spinel or sillimanite come in contact with the liquid of the magma they disappear by reaction, as they are only stable within the cordierite itself, and represent products of subsidiary reactions within the xenoliths themselves, which are permitted to act by a process of solid diffusion.

Likewise garnet may be produced by the action of biotite and cordierite, represented roughly by the following equation—



E. Effects of Reactions upon the Granodiorite.

From the equations given it will be seen that the effects of reaction have been to fix potash by the formation of micas. This will mean that the liquid is impoverished in this constituent, and when crystallization is complete the orthoclase:plagioclase ratio will be decreased. The crystallization of some plagioclase within the xenoliths will tend to keep the ratio constant, but nevertheless much of the plagioclase probably still crystallizes, as already stated, within the magma itself, on the already formed more basic plagioclase.

The amount of quartz within the liquid will be greatly augmented by the melting out both of original quartz in the hornfels, and that thrown out by the conversion of cordierite to micas.

The muscovite within the granodiorite may have been remelted, according to its position in the general igneous reaction, and again precipitated on the cooling of the magma, but it appears as though the flakes have merely floated into the liquid, with which they are in equilibrium. Therefore it would appear as though muscovite can be in equilibrium with both biotite and orthoclase.

In the more recent xenoliths the only effect has been a slight addition of quartz and subtraction of oligoclase, as the cordierite

has not started undergoing reaction. The crystals of orthoclase in the specimen of recognizable hornfels indicate that this block did not fall into the magma until the latter had reached the stage where orthoclase is normally crystallizing.

To sum up, therefore, the only effect that reaction of xenoliths and magma has had upon the latter, has been to decrease orthoclase, increase quartz, and introduce muscovite. This bears out Bowen's contention that, generally speaking, such reaction only varies the relative amounts or individual compositions of phases. The introduction of muscovite occurs, as it can probably coexist with liquids from which biotite and orthoclase can crystallize. In normal differentiation of pure igneous rocks, the alumina content does not reach a high enough value to give muscovite instead of orthoclase, till the very last stages of crystallization.

The cordierite crystals and their relics, and the dark aggregates, are so intimately mixed with the true igneous minerals of the Bulla granodiorite that an analysis will be of both granodiorite and xenoliths. The result will be to increase the percentages of the constituents MgO , FeO , and Al_2O_3 . The percentage of SiO_2 will remain fairly constant, as the percentages of this constituent in cordierite-biotite-quartz hornfels and granodiorite respectively, are comparable. The percentage within the granodiorite proper will be larger than indicated by an analysis, as nearly all the quartz now resides in the igneous rock. Following are the analyses of Bulla granodiorite, Harcourt granodiorite (?) and Gellibrand's Hill adamellite. The Harcourt rock is probably fairly typical of Victorian plutonic rocks. For the present purpose accessories are omitted.

	Bulla ⁷	Harcourt ⁸	Gellibrand's Hill ⁹
SiO_2	66.13	70.94	67.75
Al_2O_3	16.83	13.99	16.11
Fe_2O_3	1.11	0.35	0.50
FeO	4.17	3.02	4.00
MgO	1.83	0.80	0.79
CaO	3.26	2.35	2.68
Na_2O	2.25	3.94	2.60
K_2O	3.14	3.66	3.42
H_2O+	1.68	0.21	0.96
H_2O-	0.23	0.11	0.20
Analyst.	F. Watson.	G. Ampt.	H. C. Richards.

The Bulla granodiorite is seen to be richer in FeO and MgO than the Harcourt rock, which is not contaminated with accidental xenoliths. The Al_2O_3 content is also much higher. If the xeno-

7.—"The Physiography and Geology of the Bulla-Sydenham Area." A. V. G. James. Proc. Roy. Soc. Vic., Vol. XXXII. (N.S.), Pt. II., 1920.

8.—"On the Origin and Relationship of Some Victorian Igneous Rocks," H. S. Summers, *Ibid.*, Vol. XXVI., (N.S.), Pt. II., 1914.

9.—"Notes on the Geology of Broadmeadows," F. L. Stillwell, *Ibid.*, Vol. XXIV. (N.S.), Pt. I., 1911.

liths could be excluded from the former it is quite likely that the original rock would have a composition similar to the Harcourt rock. It is of interest to note that in the Gellibrand's Hill adamellite, in which dark aggregates appear to be far less numerous than in the Bulla granodiorite, and among the contact rocks of which, so far as can be made out on the surface, cordierite rocks do not appear, the MgO , FeO , Al_2O_3 contents are lower.

The granite of Big Hill, south of Bendigo, and the granodiorite of Mornington, are uncontaminated rocks, so far as their present textures and mineral contents indicate, and the contact zones of both are siliceous and lacking apparently in cordierite rocks. Whether this is merely coincidence or whether there is some significance in the fact, in the light of the contamination of the Bulla rocks, seems obscure. It would be interesting to know whether all contact zones rich in cordierite have had similar effects on the igneous rock.

In one case this is proved to be so, for at Trawool, where cordierite hornfels identical with that of Bulla is abundant in the contact zone, the intruding adamellite contains dark aggregates and cordierite crystals, one of which is seen in thin section [1686] to have properties identical with those of Bulla.

The small aggregates are very numerous throughout the granodiorite. The foliated xenoliths are not very common, while the recognizable hornfels and those a little more altered are rare. It would appear, therefore, that the small xenoliths may have belonged originally to one crop of included hornfels blocks, and since then but little inclusion of wall rock by the invading magma has taken place. This could be accounted for by a stoppage of the magma's upward and outward expansion by dynamical means after the crop of included fragments now represented by the small aggregates, had been engulfed. This phenomenon has been considered earlier in the paper to have been one factor in intensifying metamorphism, by the continuous conduction of heat through the same wall rock sediments during the period of further recrystallization.

The change of cordierite to micas is exothermic, and hence the magma regains some of the heat which it expended in forming cordierite from chlorite and sericite. This heat of reaction may have an appreciable effect in prolonging the time of final consolidation and cooling of the magma.

In describing the effects of alkaline material on cordierite-biotite-quartz hornfels by impregnation with the last stage aqueous juices of the magma, earlier in the paper it was shown that cordierite passed to serpentine and biotite to magnetite. Biotite was evidently unstable in contact with the liquid of the alkaline magma of the vein, and so passed to magnetite which seems to play a more or less neutral role in the general reaction series. Cordierite passes directly to muscovite and serpentine, the latter evidently being a very late member of a ferro-magnesian series.

4.—Summary and Conclusions.

The metamorphic contact zone at Bulla consists mainly of cordierite-biotite-quartz hornfels which are the outcome of chemical rearrangement and recrystallization of quartz-sericite-chlorite mixtures. Quartzites and sericite-biotite-quartz hornfels occur, and also lenticles of lime-silicate hornfels containing what may be prehnite, and also diopside.

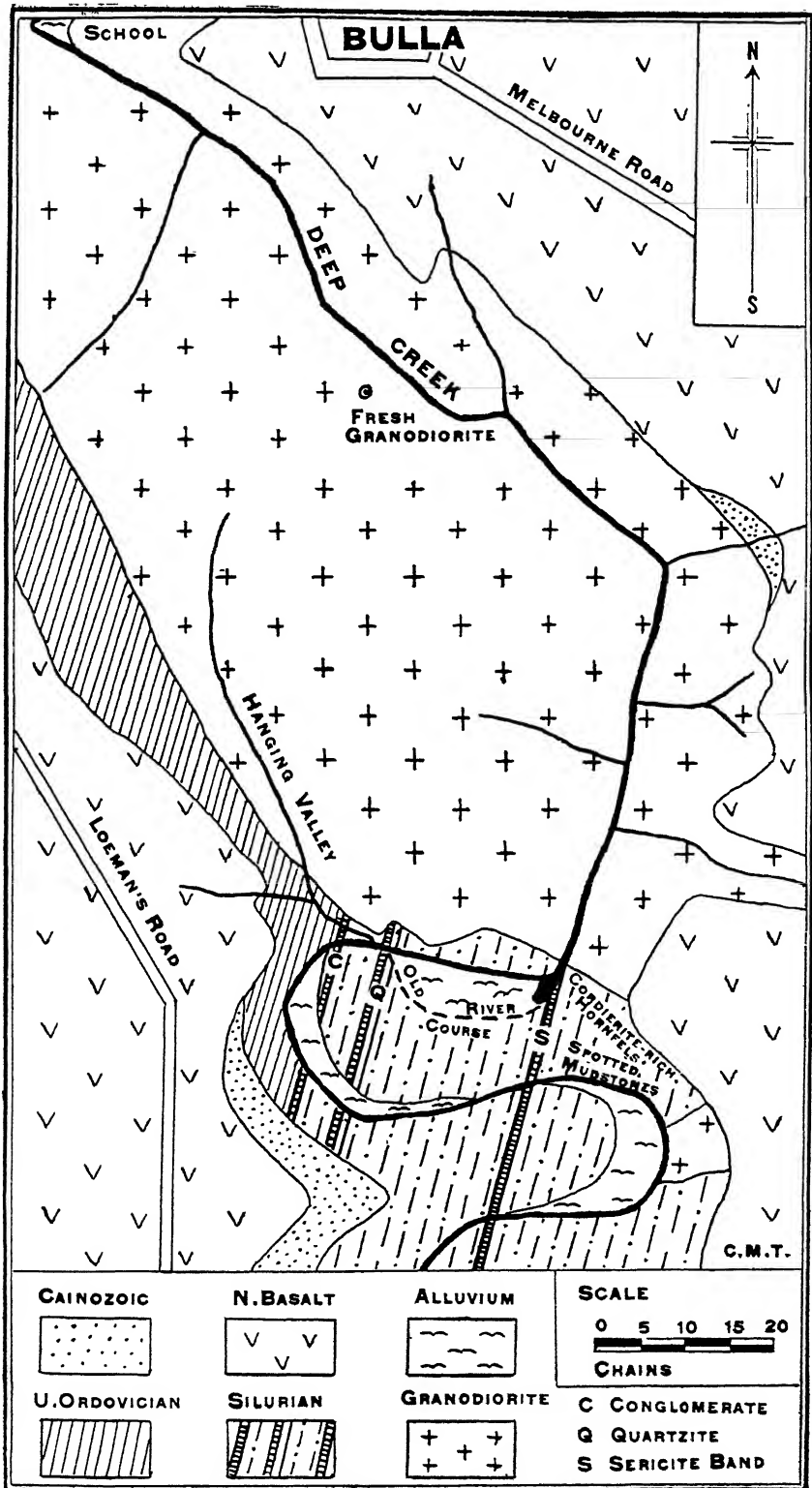
Pneumatolysis appears to have played but a small part in the recrystallization processes, but a long sustained heating of a naturally reactive mixture, naturally reactive in virtue of its heterogeneous chemical composition and water content, has probably been the cause of metamorphism.

Of interest is the vein of alkaline minerals threading through and impregnating the hornfels. It is connected with the pneumatolytic stage of the magma, but has not had an effect of intense recrystallization of the hornfels, but has reacted with the hornfels and decomposed the biotite and cordierite of the latter.

The prevalence of hydrated minerals and of amphiboles in the contact zone indicates that the temperature of metamorphism was not high.

The microscopical examination of the Bulla granodiorite shows it to be contaminated with disseminated fragments of rocks containing minerals, some of which are foreign to igneous rocks. These fragments are in the form of foliated xenoliths; smaller dark aggregates, and crystals, more or less idiomorphic, of cordierite. By the application of the reaction principle, the mineralogical associations of the xenoliths and the effect of their reaction upon the granodiorite are best accounted for. The cordierite of the xenoliths breaks up by reaction into muscovite and a pale green biotite. The muscovite is disseminated into the still liquid portion of the magma, with which it appears to be in equilibrium. The biotite of the xenoliths also tends to change over into this green form. Serpentine is also formed from the cordierite, but probably ultimately reverts back to biotite. The fixing of alkali by the xenoliths involves a decrease in the amount of orthoclase in the completely crystallized granodiorite. Quartz which at the time of reaction must be in the liquid phase, is melted out of the xenoliths, and plagioclase crystallizes within the xenoliths, or as more acid zones on previously crystallized plagioclase. The depletion of quartz within the xenoliths results in their becoming more basic, and cordierite tends to break down into sillimanite and spinel with the liberation of quartz, which is melted off, until the lowering of temperature of the whole mass checks further reaction. Biotite and cordierite may react to give rise to garnet.

In analysing the granodiorite, all small xenoliths and cordierite crystals could not be excluded, and hence the analysis is of contaminated rock, and not pure igneous rock. On this account the Bulla granodiorite is relatively high in MgO , FeO and Al_2O_3 .



Geological Map of Area South of Bulla, Victoria

The total effect of reaction has been to introduce only one new phase—muscovite—into the magma, to decrease the orthoclase: plagioclase ratio, and to increase the amount of quartz. This bears out the contention of Bowen that the effect of reaction on a magma is but slight, and that the heat reserve of granitic magmas at all events, is not sufficient to cause profound changes.

The cordierite crystals within the Bulla granodiorite and Tra-wool adamellite are unique, but it is probable that traces could be found in many other masses where the contact rocks contain this mineral. It is probable that this mineral is never primary in igneous rocks, except perhaps in certain alumina-rich norites which may owe their composition to original absorption of alumina-rich sediments by melting and diffusion under deep-seated conditions.

Many of the cases of apparent chemical reciprocal reaction between xenoliths and magma will probably be proved to be explicable by the Reaction Principle of crystallization. In the case of the xenoliths at Bulla there has been a transference of lime and alkalies to the xenoliths, and quartz to the magma, by crystallization reaction, but the nature of such transference is not truly a reciprocal chemical reaction.

In conclusion, I wish to thank Professor Skeats for suggestions and criticisms; Dr. F. L. Stillwell, for advice in setting out of the paper; and Associate Professor Summers for encouragement and help in many ways.

ART. XV.—A Note on the Symbiosis of *Loranthus* and *Eucalyptus*.

By LESLEY R. KERR, M.Sc.

(With Plate XXVIII.)

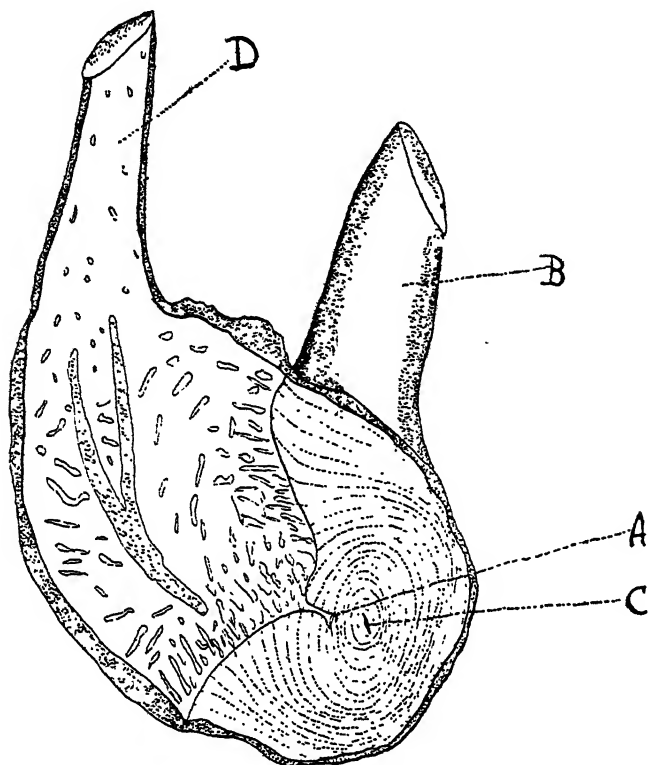
[Read 11th December, 1924.]

Although a large body of literature is available in regard to the degree of parasitism between the non-Australian species of *Viscum* and *Loranthus*, comparatively little precise information is to be found in regard to the degree of parasitism of the Australian species of *Loranthus*. The generally accepted view is that they merely receive water and salts from their host and manufacture all their own organic food materials by photosynthesis. According to Wood (1) *Loranthus quandang* growing on such an *Acacia* as the mulga (*Acacia aneura*) had a transpiration rate occasionally over eight times as great for short periods, but on the average over long periods its transpiration is between five and six times as active as that of its host, and hence during dry periods the leaves of an infected plant are bound to suffer from want of water, owing to the wasteful and extravagant transpiration rate of the parasitic mistletoe. This alone would be sufficient to explain the injurious effect of mistletoe upon a badly infected tree. In the case of a *Eucalyptus*, the disparity between the rate of transpiration of the host and of the parasite is not so great, and the possibility of a passage of elaborated food materials from the parasite to the hosts needs consideration. Various European observers have gone so far as to state that a definite symbiosis exists between the evergreen European *Viscum* and certain of the deciduous trees on which it grows; in winter time the *Viscum* supplying food materials to its leafless host.

Brittlebank (2) states that in the case of *Loranthus exocarpi* at the point of contact one (or occasionally more than one) sinker is commonly developed, which bores through the stem and appears on the opposite side, where it broadens to form a dovetail connection. He also figures remarkable cases of star-like formations of *Loranthus* tissues resembling broad medullary rays in the tissues of the host plant.

None of these remarkable appearances has been seen in *L. pendulus*. Here the parasite does not penetrate further after it has reached the wood, and the subsequent growth is lateral, while at the junction line, the tissues interlace without either penetrating deeply in the other. Occasionally at the border line, owing to the crumpling of the tissues, an external appearance resembling the formation of ingrowths may develop, but this is merely because

the two cambiums are somewhat folded. There is no boring of the parasite into the wood of the host after the wood has once developed.



TEXT-FIGURE I.

Section of point of union between the tissues of *L. pendulus* and *Eucalyptus hemiphloia* var. *microcarpa* before the death of the distal end of the shoot. A, disc by which the *Loranthus* attached itself to the tissues of the host; B, stem of host; C, original centre of growth of the stem of the host; D, stem of parasite.

Text-Fig. 1 shows a section of the point of union between the tissues of *L. pendulus* and *Eucalyptus hemiphloia* var. *microcarpa* before the death of the distal end of the shoot had taken place. At C, the original centre of growth of the stem is shown, and at A, the disc by which the *Loranthus* attached itself to the tissues of the host. All the growth has taken place on the outside of the stem of the host, and has resulted in a distortion of the annual rings. The growth of the parasite begins laterally, but, owing to the removal of large quantities of water from the branch by the parasite, the terminal portion of the branch is gradually killed, and

the parasite ultimately assumes a terminal position provided the branch was infected while young.

Brittlebank (2) draws attention to the fact that at the point of junction starch is much more abundant in the *Loranthus* tissue than in the tissue of the host plant. He concludes from this fact that the *Loranthus* is drawing starch from its host. In all such cases, however, there is more or less of a block in the translocation channel at the point of junction between the host and the parasite, so that if starch were passing from the host to the parasite an accumulation of starch should be shown, it is true, at the point of junction, but it would be in the tissues of the host and not in that of the parasite. The real explanation appears to be, firstly, that the tissues of the *Loranthus* are less woody, and contain more starch-bearing parenchyma, and, secondly, that the *Loranthus* uses its enlarged base as a storage place for starch manufactured in its own leaves.

Some observations recently made in the field seem to show that *Loranthus* can supply food materials to a leafless host, and to indicate that for a time at least a *Eucalyptus* stock which has no foliage of its own can be nourished by a parasitic *Loranthus*, i.e. that a relationship may be established analogous to that between the stock and scion in a grafted plant.

A few preliminary observations did not indicate so pronounced a difference between the rates of transpiration of the hanging mistletoe (*L. pendulus*) and of plants of *Eucalyptus hemiphloia*, on which it was parasitic, as that observed by Wood in the case of the mulga and *L. exocarpi*. In the case of *L. pendulus* and *E. polyanthemus*, the former appeared to have an average transpiration rate for equal leaf areas, about four times as great as that of the host when both were under optimal conditions for transpiration. Isolated leaves of mistletoe have little control over their transpiration rate, and droop rapidly, whereas in the case of isolated leaves of *Eucalyptus* the transpiration rate soon falls, so that the leaf cells remain turgid for long periods of time.

The following observations indicate strongly the possibility of a food transference. Trees can often be seen living which bear much more mistletoe foliage than they do of their own. In Long Forest a natural graft of *Loranthus pendulus* on *Eucalyptus hemiphloia* var. *microcarpa* (Fig. A of Plate) is growing, and is nearly five feet high. It has now been under observation for three years. On November 1st, 1923, though the stock bore no eucalypt leaves, the mistletoe was fruiting freely. Up to December, 1924, the plant was still vigorous, and again fruiting. Both stock and scion were growing in diameter, so that the stock must have received food materials from the scion. It is proposed later to examine the amount of wood formed on each part of this natural graft. Another graft was found in the Ironbark Forest on March 15th, 1924 (Fig. B of Plate). It was 7 feet high, with a long leg of *Eucalyptus sideroxylon* bearing seven leaves only, and a terminal cluster of *Loranthus pendulus*. The eucalypt



Fig. B



Fig.

leaves were removed, and up to December, 1924, the plant has grown freely. A similar growth of *L. pendulus* on a leafless stock of *E. Behriana* was found in Long Forest during October, 1924, and the stock shows no signs of starvation. A fourth specimen of *L. pendulus* on a leafless stock of *E. polyanthemos* was found at Goodman's Creek, and for experimental purposes four artificial grafts of *L. pendulus* on leafless *E. polyanthemos* stocks have been prepared, and will be kept under observation to determine the relative rate of growth and production of wood in stock and scion. There seems, however, already, reason to suppose that a mistletoe scion is capable of nourishing a leafless eucalyptus stock for a time at least. Probably these natural grafts will be likely to suffer during dry seasons, and hence are unlikely to develop into growths of very large size or to last indefinitely. It is proposed to keep them under observation as long as possible, and to take detailed measurements of the relative growth of the stock and parasitic scion.

In concluding this brief preliminary note, I have to thank Professor Ewart for emphasising the importance of these natural *Loranthus*-*Eucalyptus* grafts when I first drew his attention to their existence.

Literature cited.

- (1) Wood. *Trans. Roy. Soc. S.A.*, xlviii., 1924.
- (2) Brittlebank. *Proc. Linn. Soc. N S W.*, xxxiii. (3), 1908.

EXPLANATION OF PLATE.

Fig. A.—Natural graft of *L. pendulus* on *E. hemiphloia* var. *microcarpa*.

Fig. B.—Natural graft of *L. pendulus* on *E. sideroxylon*.

ANNUAL REPORT OF THE COUNCIL

FOR THE YEAR 1924.

The Council presents to Members of the Society the Annual Report and Statement of Receipts and Expenditure for the past year.

The following meetings were held:—

March 13—Annual Meeting.

The following office-bearers retired by effluxion of time: President, F. Wisewould; Vice-Presidents, Professor Laby, Dr. Baldwin; Hon. Secretary, J. A. Kershaw; Hon. Treasurer, Dr. E. Kidson; Hon. Librarian, A. S. Kenyon; Members of Council, Professor Skeats, Professor Agar, Dr. Green, Messrs. F. Chapman, Herman, Gray.

The following were elected: President, Professor Laby; Vice-Presidents, Dr. Baldwin, Dr. A. E. V. Richardson; Hon. Treasurer, Dr. E. Kidson; Hon. Librarian, Dr. W. J. Young; Hon. Secretary, J. A. Kershaw; Members of Council, Professor Skeats, Professor Agar, Professor Ewart, Professor Michell, Dr. Green, Captain Davis.

The Annual Report of the Council and Financial Statement were read and adopted.

At the close of the Annual Meeting, an Ordinary Meeting was held. Papers: (1) "On Some New Australian Chrysomelidae (Coleoptera)," by Arthur M. Lea, F.E.S.; (2) "A Revision of the Cainozoic Species of *Glycymeris* in Southern Australia," by Fredk. Chapman, A.L.S., and F. A. Singleton, M.Sc.; (3) "The Distribution of Anopheline Mosquitoes in the Australian Region, with Notes on some *Cuciline* Species," by G. F. Hill (communicated by J. A. Kershaw).

Professor A. C. D. Rivett, D.Sc., Mr. Anderson, and Miss Sybil Llewelyn, M.A., M.Sc., were elected members, and Miss D. K. Ross, M.A., M.Sc., and Mr. Ralph Merle Limborn Associates.

March 27th:—A meeting of the Mathematical and Physical Section was held in the Society's hall. Lecture, "On Some Mathematical Aspects of the Theory of Relativity," by Professor J. H. Michell, M.A., F.R.S.

April 24th:—Address on "Diffraction Gratings," by Sir Thomas R. Lyle, M.A., Sc.D., F.R.S., assisted by Mr. Z. A. Merfield.

The Hon. Sir William McPherson, K.B.E., was elected a Member, and Messrs. Gerald F. Hill and J. Malcolm Sinclair Associates.

May 8th:—Paper: "The Nutrient Value of Artificial Sugar," by Professor A. J. Ewart, D.Sc., Ph.D., F.R.S. A discussion

followed on "The Inheritance of Acquired Characteristics," introduced by Professor W. E. Agar, D.Sc., F.R.S.

Messrs. B. A. Smith, M.C.E., and J. S. Rogers, B.A., M.Sc., were elected Members, and Messrs. J. Shearer, M.Sc., E. L. Sayce, J. M. Allen, and E. J. G. Pitman, M.A., B.Sc., Associates.

May 15th:—Mathematical and Physical Section. Continuation of the address by Professor Michell on "Some Mathematical Aspects of the Theory of Relativity."

June 12th:—Papers: (1) The Lignotubers of Eucalypt Seedlings," by Miss Lesley R. Kerr, M.Sc.; (2) "New or Little-known Fossils in the National Museum, Part XXVIII. Some Silurian Rugose Corals," by Frederick Chapman, A.L.S.

Dr. W. J. Young was elected Hon. Secretary to the Society.

Mr. C. M. Tattam, B.Sc., and Mr. J. A. Feely were elected Associates.

June 19th:—Mathematical and Physical Section. Lecture, "The Micro-Structure of Metals," by Professor J. N. Greenwood, D.Sc.

July 4th:—A Special Meeting of the Society was held to commemorate the centenary of the birth of Lord Kelvin. A series of short addresses on the various phases of his life and work was delivered as follows:—(1) "His Life and Character," by Professor W. A. Osborne, M.B., B.Ch., D.Sc.; (2) "His Work"—(a) "Thermodynamics," by E. F. J. Love, M.A., D.Sc.; (b) "Mathematics," by Professor J. H. Michell, M.A., F.R.S.; (c) "Electricity and Inventions," by Professor T. H. Laby, M.A., Sc.D., F.Inst.P.

July 17th:—Papers: (1) "Notes on *Mastomys darwiniensis* Froggatt (Isoptera)," by Gerald F. Hill; (2) "A Revision of the Genus *Pultenaea*, Part IV.," by H. B. Williamson; (3) "Sunspots and Australian Rainfall," by E. T. Quayle, B.A. Lecture on "The Graduation of Circles," by Jas. A. Smith.

Dr. Arnold Caddy was elected a Member, and Miss Edith Nelson, M.A., M.Sc., Miss M. I. Allfrey and Mr. D. G. Salier Associates.

August 14th:—Papers: "Some Periods in Australian Weather," by E. Kidson, O.B.E., D.Sc., F.Inst.P. Lecture on "Selwyn the Geologist," by E. J. Dunn. Professor Osborne exhibited a blow gun, and exhibits were also shown by Professor Laby.

Mr. J. A. Kershaw was elected Hon. Librarian, and Miss Margaret Long, B.Sc., Messrs. H. D. Ingram, and E. H. Cox Associates.

September 19th:—A discussion was held on "Hydrogen Ion Concentration—Its Measurement, and Practical Application." The following aspects were considered:—(1) "The Theory of Hydrogen Ion Concentration," by E. F. J. Love, D.Sc.; (2) "Methods of Measurement," by F. J. Considine; (3) "A

Demonstration of the Electrometric Method," by J. M. Lewis, D.D.Sc.; (4) "Its Importance in Bacteriology," by F. G. Morgan, M.D.; (5) "Application in the Preparation of Insulin," by G. V. Rudd, M.Sc.; (6) "Hydrogen Ion Concentration in Industrial Chemistry, Manufacture of Glue, and Tannery Operations," by I. H. Boas, M.Sc.

October 9th:—Papers: (1) "The Bacchus Marsh Basin, Victoria," by C. Fenner, D.Sc.; (2) "Stock Poisoning in the Northern Territory," by Professor A. J. Ewart, D.Sc., Ph.D., F.R.S.

Mr. John Wren Sutton was elected a Country Member, and Messrs. J. McA. Finney and J. S. Reid Associates.

October 16th:—Mathematical and Physical Section. Lecture: "Co-ordination Numbers and the Bohr Atom," by Professor A. C. D. Rivett, D.Sc.

November 13th:—Lecture: "Nauru; a Description of the Island and Its People," by Dr. Harold Dew.

Dr. Douglas Thomas was elected a Member, and Engineer-Commander P. Mackenzie, R.N. (retired), a Country Member.

November 20th:—Mathematical and Physical Section. Papers: "The Mechanical Equivalent of Heat," by Professor T. H. Laby, M.A., Sc.D., and Mr. E. O. Hercus, M.Sc.; "The Thermal Conductivity of Gases" (a contribution to the International Critical Tables), by Professor T. H. Laby, M.A., Sc.D., and Miss Nelson, M.Sc. Lantern slides, showing changes which occur on the refrigeration of beef, were shown by Dr. W. J. Young and Mr. J. R. Vickery, B.Sc., and exhibits of wireless apparatus and a loud speaker by the Western Electric Company.

December 11th:—Papers: (1) "Monograph on Australian Fossil Polyplacophora," by E. Ashby, F.L.S.; (2) "A Landslip near Mornington," by T. Baker; (3) "Termites from the Australian Region; Descriptions of New Species and Hitherto Undescribed Castes," by G. F. Hill; (4) "Contact Metamorphism in the Bulla Area, and Some Factors in the Differentiation of the Granodiorite of Bulla, Victoria," by C. M. Tattam, B.Sc.; (5) "The Symbiosis of Loranthus and Eucalyptus," by Lesley R. Kerr, M.Sc.

During the year ten Members, two Country Members, and sixteen Associates were elected; three resigned, and two Members and one Associate died.

The Council regrets to record the loss by death of Mr. Henry Deane, Mr. James E. Gilbert, and Mr. William Henry Finney.

Mr. Henry Deane, M.A., M.Inst.C.E., F.L.S., F.R.Met. Soc., F.R.H.S., who died suddenly at Malvern, Victoria, on March 12, 1924, was born at Clapham, England, on March 26, 1847.

He matriculated at Queen's College, Galway, in 1862, and in 1865 obtained the degree of B.A. of the Queen's University

of Ireland, taking honours in mathematics and the natural sciences. He subsequently obtained the degree of M.A. of the same University, and in later years the *ad eundem* degree of M.A. of the University of Sydney, N.S.W.

Mr Deane had a distinguished engineering career. After spending two years in the office of the late Sir John Fowler, in Westminster, he was engaged from 1869 to 1879 in railway and bridge construction in Hungary, England, and the Philippine Islands. In 1889 he came to Australia, and joined the N.S.W. railways, where, for many years, he was the chief engineer for construction, retiring in 1906. In 1908 he was appointed consulting engineer in connection with the survey of the Transcontinental Railway from Perth to Port Augusta, and in 1910 became Engineer-in-Chief to this Railway. He settled in Victoria in 1913.

Mr. Deane had wide scientific interests. He was twice President of the Royal Society of New South Wales, and President of the Linnean Society of New South Wales. In 1914 he joined the Royal Society of Victoria.

He was specially interested in the study of native timbers, and, in conjunction with Mr. J. H. Maiden, published a series of papers on the subject in the proceedings of the Linnean Society of N.S.W. He also published numerous papers on forestry, orchids, etc., and quite recently completed a monograph on the dicotyledonous leaves of Morwell. At the time of his death Mr. Deane was engaged at the Natural History Museum in Melbourne on investigations on the Bacchus Marsh fossil plant remains, and on a revision of the whole of the fossil fruits from the deep leads of Victoria.

Mr. James E. Gilbert was born in the year 1842, and, with the exception of Mr. Ellery, was the first permanent officer at the Observatory, then situated at Williamstown, where, as a boy of 14 years of age, he commenced as messenger on July 28, 1856. He was soon engaged in the duties of a junior assistant, making meteorological observations, assisting in computing, reading off chronograph sheets, etc. He was promoted to the position of junior assistant in 1861, and assistant in 1871. His work at the Observatory was mainly in connection with the meridian observing and computing, in which he acted as assistant to Mr. White, but he also carried out the duties of accountant and storekeeper. In May, 1887, he was promoted to a position in the G.P.O. In 1872 he was elected a Life Member of the Society, and was, therefore, at the time of his death, the oldest Member. He was elected one of the two Hon. Auditors of the Society in 1901, a position which he filled until 1923. He died on September 11, 1924.

Mr. William Henry Finney was born on April 11, 1858, at Jersey City, U.S.A., and came to Australia at the age of six. After leaving school in Albert Park, Melbourne, he went into

commercial life. In later years his health broke down, and for the last three years of his life he was an invalid. He died at his residence in Albert Park on August 9, 1924. Mr. Finney became an Associate of the Royal Society in 1881, and was one of the oldest Associates.

The meetings of the Society have been very well attended during the year, and several interesting discussions have been held. This especially applies to the Mathematical and Physical Section, and, although only one paper has been presented in this Section for publication, the majority of lectures dealt with original work done in Melbourne, much of which was of high standard. The Section has, therefore, filled a want long felt by workers in the physical sciences. Similar Sections are being established by the Royal Societies in other States, and it is hoped that co-operation with these will be possible.

Mr. J. A. Kershaw resigned from the position of Hon. Secretary, which he has filled so ably for some time.

The Council has to record with regret the resignation of Dr. A. E. V. Richardson from the Society, on his appointment to the Peter Waite Agricultural Institute in Adelaide. Dr. Richardson has been a member for many years, and has served the Society both on the Council and as one of the Auditors.

During the year the Council, at several meetings, considered the question of increasing the usefulness of the Society, and the possible removal to a more central position has been discussed. It was decided that it would be inadvisable for the Society to move, and that efforts should be made to improve the condition of the hall and grounds.

The Government of Victoria was approached, and the Society has to thank the Ministry for undertaking the renovation of the hall, both inside and outside, and the erection of a new wire fence. This work is now in hand, and the hall will be ready when the meetings recommence in March. It is proposed to improve the grounds in the near future.

The Librarian reports that 1654 volumes and parts have been received during 1924.

Part II. of Volume XXXVI. of the Proceedings was issued in August, and Parts I. and II. of Volume XXXVII. are now in hand.

HONORARY TREASURER'S REPORT

The financial position of the Society has improved somewhat during the past year. This is due chiefly to the restoration of the Government grant to £200. The execution of the promised repairs to the hall and cottage, also, has relieved the Council of considerable anxiety on the score of finance.

The amount received from subscriptions was slightly less than in 1923. It is disappointing to find that this falling-off is due to the larger proportion of unpaid subscriptions.

The improved conditions early in the year allowed the Council to return to the Savings Bank fund the amount withdrawn in 1922 with interest, and to deposit a further £150. Unfortunately, the benefit of these economies has been almost entirely lost through the excessive cost of the second part of the Proceedings for 1923, and the expected heavy bill for the first part of the 1924 volume. These liabilities might have been reduced materially without affecting the value of the Proceedings (1) had papers been subjected to a more rigid refereeing, and (2) had they not been received by the Council until in their final form. The Hon. Treasurer is very strongly of the opinion that a recurrence of the experience of last year should be rendered impossible.

The expenses in connection with the renovation of the hall and cottage will not end with the completion of the Government's part in the matter. It is obvious that a very great improvement is called for in the condition of the grounds. A large number of new chairs, a lantern, and other fittings will be required. It was with these needs in view that the additions were made to the Savings Bank fund.

The Society is no nearer the acquisition of a satisfactory lecture theatre, though much thought was given to the matter during the year. The Council will have seriously to consider whether it should not renew its attempts to let a portion of the grounds.

Financial Statement for period February 1st, 1924, to December 31st, 1924.

RECEIPTS.				EXPENDITURE.			
Balance at Current A/c, 1st February, 1924	£253	8	9	Publication, Printing and Postage—			
Cash in hand ... ..	...	0	3	Printing and Publication	£286	7	9
Subscriptions—				Postage	20	12	11
Members—Subs. in arrears	£2	2	0				£307 0 8
" for 1924	154	7	0	Maintenance—			
" in advance	2	2	0	Assistant Secretary	...	£30	0 0
Associates—				Assistant Librarian	...	12	0 0
Subs. in arrears	13	13	0	Caretaker's A/cs.	...	20	12 2
" for 1924	84	10	6	Rates	...	13	11 8
" in advance	2	2	0	Insurance ... ..	...	6	1 3
Country Members—				Sundries — Gas, Electric	...		
Subs. in arrears	1	1	0	Light, etc.	...	11	9 8
" for 1924	12	12	0	Petty Cash	...	7	16 5
" in advance	2	2	0				100 11 2
Rents—			274 11 6	Library ... ..	...	...	7 6 8
Commonwealth Government	£62	10	0	Building and Depreciation Fund, Deposits	...	...	354 8 8
Field Naturalists' Club...	12	0	0				£769 6 2
Microscopical Society ...	12	0	0				
Sales of Publications	...	...	86 10 0	Credit balance as on 31/12/24—			
Victorian State Government Grant in Aid	...	...	3 8 3	Current Account	...	£47	19 2
Exchange on Cheques	...	...	200 0 0	Cash in Hand	...	1	4 1
	...	...	0 7 6				49 3 3
			£818 9 5				£818 9 5

We have examined Pass Books and hereby certify that all amounts entered herein have been paid to, the credit of the Society. We have seen receipts for all payments.

EDWARD KIDSON, *Hon. Treas.*

27/2/25

C. A. LAMBERT, } *Hon.*
J. SHEPHERD, } *Auditors.*

The amount standing to the credit of the Society at the State Government Savings Bank on 1/7/24 was £611 16s. 2d
Subscriptions still owing for 1924 were—Members £18 18 0
Associates 19 19 0
Country Members 3 3 0

Country Members £42 0 0

Liabilities to Messrs. Ford & Son for printing Proceedings are £123 3s.

In addition, the 1924 Volume of the Proceedings which is in process of publication is estimated to cost £300.

Royal Society of Victoria.

1924.

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HIS EXCELLENCY THE RIGHT HON. THE EARL OF STRADBROKE, K.C.M.G.,
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1925.

LIST OF MEMBERS

WITH THEIR YEAR OF JOINING.

[Members and Associates are requested to send immediate notice of any change of address to the Hon. Secretary.]

PATRON.

His Excellency, The Right Hon. The Earl of Stradbroke

HONORARY MEMBERS.

- Liversidge, Professor A., LL.D., F.R.S., "Field-head," George-road, Coombe Warren, Kingston, Surrey, England. 1892
- Verbeek, Dr. R. D. M., Speelmanstraat, 19, s'Gravenhage, Holland. 1886

LIFE MEMBERS.

- Fowler, Thos. Walker, M.C.E., "Fernhill," 8 Fitzwilliam-steet, Kew. 1879
- Gregory, Prof. J. W., D.Sc., F.R.S., F.G.S., University, Glasgow. 1900
- Love, E. F. J., M.A., D.Sc., F.R.A.S., Moreland Grove, Moreland. 1888
- Selby, G. W., Glenbrook-avenue, Malvern. ... 1889
- Smith, W. Howard, "Morton," Esplanade, St. Kilda ... 1911

ORDINARY MEMBERS.

- Agar, Prof. W. E., F.R.S., M.A., D.Sc., University, Carlton. 1920
- Anderson, George, M.A., LL.M., 222 Beaconsfield-parade, Middle Park, 1924
- Austin, E. G., Boeri Yallock, Skipton ... 1922
- Baker, Thomas, Bond-street, Abbotsford ... 1889
- Baldwin, J. M., M.A., D.Sc., Observatory, South Yarra 1915
- Bale, W. M., F.R.M.S., 83 Walpole-street, Kew ... 1887
- Balfour, Lewis J., B.A., M.B., B.S., Burwood-road, Hawthorn. 1892
- Baragwanath, W., Geological Survey Dept., Melb. ... 1922
- Barrett, A. O., 25 Orrong-road, Armadale ... 1908
- Barrett, Sir J. W., K.B.E., C.M.G., M.D., M.S., Collins-street, Melbourne. 1910
- Brittlebank, C. C., 48 York-street, Caulfield ... 1898

Casey, R. G., 125 William-street, Melbourne	1922
Chapman, F., A.L.S., National Museum, Melbourne ...	1902
Cudmore, F. A., 17 Murphy-street, South Yarra	1920
Davis, Captain John King, "Tasma," Parliament- place, Melbourne.	1920
Dunn, E. J., F.G.S., "Roseneath," Pakington-street, Kew.	1893
Dyason, E. C., B.Sc., B.M.E., 92 Queen-street, Melb.	1913
Ewart, Prof. A. J., D.Sc., Ph.D., F.R.S., F.L.S., Uni- versity, Carlton.	1906
Gault, E. L., M.A., M.B., B.S., Collins-street, Melb.	1899
Gilruth, J. A., D.V.Sc., M.R.C.V.S., F.R.S.E., 520 Munro-street, South Yarra.	1909
Gray, Wm., M.A., B.Sc., Presbyterian Ladies' College, East Melbourne.	1913
Green, W. Heber, D.Sc., University, Carlton	1896
Grimwade, W. Russell, B.Sc., 420 Flinders-lane, Melb.	1912
Grut, P. De Jersey, F.R.Met.S., 103 Mathoura-road, Toorak.	1869
Harrison, Flying Officer H. C., A.R.C.S., R.A.A.F. 1923 Headquarters, Vic. Barracks, St. Kilda-road, Melbourne.	
Herman, H., D.Sc., B.C.E., M.M.E., F.G.S., "Albany," 8 Redan-street, St. Kilda.	1897
Horne, Dr. G., Lister House, Collins-street, Melbourne	1919
Janssens, Eugene, 2 Argyle-street, St. Kilda	1923
Kelly, Bowes, Glenferrie-road, Malvern	1919
Kenyon, A. S., C.E., Lower Plenty-road, Heidelberg ...	1901
Kernot, Assoc. Prof. W. N., B.C.E., University, Carlton.	1906
Kershaw, J. A., F.E.S., National Museum, Melbourne	1900
Kidson, E., O.B.E., M.A., D.Sc., F.Inst.P., Meteor- ological Bureau, Melbourne.	1921
Laby, Prof. T. H., M.A., Ph.D., Sc.D., F.Inst.P., Uni- versity, Carlton.	1915
Laidlaw, W., B.Sc., Botanical Gardens, Domain, South Yarra.	1911
Lewis, J. M., D.D.Sc., "Whitethorns," Boundary-road, Burwood.	1921
Littlejohn, W. S., M.A., Scotch College, Melbourne ...	1920
Llewelyn, Miss Sybil, M.A., M.Sc., Education Dept., Melbourne.	1924
Lyle, Prof. Sir Thos. R., M.A., D.Sc., F.R.S., Irving- road, Toorak.	1889

MacKenzie, W. Colin, M.D., B.S., F.R.C.S., 88 Collins-street, Melbourne.	1910
Mahony, D. J., M.Sc., "Lister House," Collins-street, Melbourne.	1904
Mann, S. F., Caramut, Victoria	1922
Masson, Prof. Sir David Orme, K.B.E., M.A., D.Sc., F.R.S.E., F.R.S., 14 William-street, South Yarra.	1887
McCallum, Dr. Gavin, 127 Collins-street, Melbourne ...	1925
McPherson, The Hon. Sir William, K.B.E., Coppin-grove, St. James's Park, Hawthorn.	1924
Merfield, C. J., F.R.A.S., Observatory, South Yarra ...	1913
Merfield, Z. A., "The Righi," South Yarra	1923
Michell, Prof. J. H., M.A., F.R.S., 52 Prospect Hill-road, Camberwell.	1900
Millen, Senator J. D., Batman House, 103 William-street, Melbourne.	1920
Miller, Leo. F., "Moonga," Power-avenue, Malvern ...	1920
Miller, E. Studley, 396 Flinders-lane, Melbourne	1921
Monash, Lieutenant-General Sir John, G.C.M.G., K.C.B., Doc. Eng., LL.D., State Electricity Commission, 22 William-street, Melbourne.	1913
Mullett, H. A., B.Ag.Sc., Dept. of Agriculture, Melbourne.	1923
Osborne, Prof. W. A., M.B., B.Ch., D.Sc., University, Carlton.	1910
Owen, W. J., 935 Rathdown-street, N. Carlton	1919
Patton, R. T., B.Sc., M.F., Regent-street, Elsternwick.	1922
Payne, Prof. H., M.Inst.C.E., M.I.M.E., University, Carlton.	1910
Penfold, Dr. W. J., M.B., "Brampton," Serum Laboratories, Royal Park.	1923
Picken, D. K., M.A., Ormond College, Parkville	1916
Piesse, E. L., 43 Sackville-street, Kew	1921
Pratt, Ambrose, M.A., 376 Flinders-lane, Melbourne ...	1918
Quayle, E. T., B.A., 26 Collins-street, Essendon	1920
Reid, J. S., 498 Punt-road, South Yarra	1924
Rivett, Prof. A. C. D., M.A., D.Sc., University, Carlton	1911
Rogers, J. Stanley, B.A., M.Sc., University, Carlton ...	1924
Schlapp, H. H., 31 Queen-street, Melbourne	1906
Shephard, John, "Norwood," South-road, Brighton Beach.	1894
Shillinglaw, Godfrey V., 64 Dandenong-road, Caulfield.	1925
Skeats, Prof. E. W., D.Sc., A.R.C.S., F.G.S., University, Carlton.	1905
Smith, B.A., M.C.E., Mutual Building, 395 Collins street, Melbourne.	1924
Spencer, Prof. Sir W. Baldwin, K.C.M.G., M.A., D.Sc., F.R.S., National Museum, Melbourne.	1887

Summers, Associate Prof. H. S., D.Sc., University, Carlton.	1902
Sweet, Associate Prof. Georgina, D.Sc., University, Carlton.	1906
Thirkell, Geo. Lancelot, B.Sc., 4 Grace-street, Mal- vern.	1922
Thomas, D. J., M.D., 12 Collins-street, Melbourne. ...	1924
Trinder E. E., "Ruzilma," Orrong-grove, Caulfield	1922
Walcott, R. H., Technological Museum, Melbourne. ...	1897
Wickens, C. H., F.I.A., F.S.S., Commonwealth Statis- tician, Rialto, Collins-street, Melbourne.	1923
Wisewould, F., "Mona," Pakenham Upper, Victoria	1902
Woodruff, Prof. H. A., M.R.C.S., L.R.C.P., M.R.C.V.S., Veterinary School, Parkville.	1913
Young, Assoc. Prof. W. J., D.Sc., University, Carlton	1923

COUNTRY MEMBERS.

Caddy, Dr. Arnold, "Chandpara," Tylden, Vic. ...	1924
Crawford, W., Gisborne, Vic.	1920
Dare, J. H., B.Sc., State School 2605, Rathdown-street, Carlton.	1917
Drevermann, A. C., Longerenong Agricultural College, Dooen, Vic.	1914
Easton, J. G., "Kiewa," Murphy-street, Bairnsdale, Vic.	1913
Ferguson, E. W., M.B., Ch.M., "Timbrebongie," Gordon-road, Roseville, Sydney, N.S.W.	1913
Harris, W. J., B.A., High School, Echuca, Vic. ...	1914
Hart, T. S., M.A., B.C.E., F.G.S., School of Mines, Bairnsdale, Vic.	1894
Hope, G. B., B.M.E., "Carrical," Hermitage-road, Newtown, Geelong, Vic.	1918
James, A., B.A., M.Sc., High School, St. Arnaud, Vic.	1917
Kitson, A. E., C.M.G., C.B.E., F.G.S., 29 Alfred- place, S. Kensington, London, S.W.7, England.	1894
Langford, W. G., M.Sc., B.M.E., Vailala Oilfields, Popo, via Port Moresby, Papua.	1918
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Mackenzie, H. P., Engr.Comm., R.N., Trawalla, Vic.	1924
Mollison, Miss E., M.Sc., Royal-crescent, Camberwell.	1915
Oliver, C. E., M.C.E., Mt. Dandenong North	1878

Sutton, J. W., 127 Doncaster-avenue, Kensington, Sydney, N.S.W.	1924
Trebilcock, Captain R. E., M.C., Wellington-street, Kerang, Vic.	1921
Turner, A. Jefferis, M.D., F.E.S., Wickham Terrace, Brisbane, Q'land.	1922
White, R. A., B.Sc., School of Mines, Bendigo, Vic. ...	1918

CORRESPONDING MEMBER.

Lucas, A. H. S., M.A., B.Sc., Sydney Grammar School, Sydney, N.S.W.	1895
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ASSOCIATES.

Allen, J. M., B.A., 399 Dandenong-road, Armadale. ...	1924
Allen, Miss N. C. B., B.Sc., University, Carlton. ...	1918
Allfrey, Miss M. I., 42 Cowper-street, Sandringham. ...	1924
Archer, Howard R., B.Sc., University Club, 294 Collins street, Melbourne.	1921
Ashton, H., "The Sun," Castlereagh-street, Sydney, N.S.W.	1911
Bage, Mrs. Edward, "Cranford," Fulton-street, St. Kilda.	1906
Bage, Miss F., M.Sc., Women's College, Kangaroo Point, Brisbane, Queensland.	1906
Baker, F. H., 167 Hoddle-street, Richmond	1911
Barkley, H., Meteorological Bureau, Melbourne	1910
Bordeaux, E. F. J., G.M.V.C., B.ès. L., Mangalore-street, Flemington.	1913
Breidahl, H., M.Sc., M.B., B.S., 23 Chatsworth-avenue, North Brighton.	1911
Brodribb, N. K. S., Cordite Factory, Maribyrnong ...	1911
Brookes, Leslie R., B.A., 3 Fern-avenue, Windsor ...	1922
Bryce, Miss L. M., B.Sc., 22 Victoria-avenue, Canterbury.	1918
Buchanan, G., D.Sc., University, Carlton.	1921
Chapple, Rev. E. H., The Manse, Warrigal-Road, Oakleigh.	1919
Clinton, H. F., Produce Office, 605 Flinders-street, Melbourne.	1920
Cook, G. A., M.Sc., B.M.E., 18 Elphin-grove, Hawthorn.	1919
Cookson, Miss I. C., B.Sc., 154 Power-street, Hawthorn	1916
Coulson, A. L., M.Sc., D.I.C., F.G.S., "Finchley," King-street, Elsternwick.	1919
Cox, E. H., Literary Staff, "The Argus," Collins-street, Melbourne.	1924
Crespin, Miss I., B.A., 67 Studley Park-road, Kew.	1919

Danks, A. T., 391 Bourke-street, Melbourne	1883
Deane, Cedric, 14 Mercer-road, Malvern	1923
Esserman, N. A., Research Laboratories, Maribyrnong	1923
Feely, J. A., Observatory, South Yarra	1924
Fenner, C. A., D.Sc., Education Department, Flinders-street, Adelaide, S.A.	1913
Ferguson, W. H., 37 Brinsley-road, E. Camberwell ...	1894
Finney, J. M., 40 Merton-street, Albert Park	1925
Flecker, Dr. H., 71 Collins-street, Melbourne	1922
Gabriel, C. J., 293 Victoria-street, Abbotsford	1908
Hardy, A. D., F.L.S., Forests Department, Melbourne	1903
Hartung, Assoc. Prof. E. J., D.Sc., University, Carlton.	1923
Hauser, H. B., M.Sc., Geology School, University, Carlton.	1919
Hercus E. O., M.Sc., A.Inst.P., University, Carlton ...	1923
Heslop, G. G., D.V.Sc., Veterinary School, Parkville.	1923
Hill, Gerald F., National Museum, Melbourne. ...	1924
Holmes, W. M., M.A., B.Sc., Observatory, South Yarra	1913
Horning, Eric, Newman College, Carlton	1924
Howitt, A. M., Department of Mines, Melbourne	1910
Ingram, H. D., 133 Barkly-street, N. Fitzroy.	1924
Jack, A. K., M.Sc., 49 Aroona-road, Caulfield	1913
Jona, J. Leon, M.D., B.S., D.Sc., "Hazelmere," Wattle Tree-road, Malvern.	1914
Jones, Miss K. A. Gilman, Church of England Girls' Grammar School, Anderson-street, S. Yarra.	1922
Jutson, J. T., B.Sc., "Vailima," Jolimont-terrace, Jolimont.	1902
Keartland, Miss B., M.Sc., Cramer-street, Preston ...	1919
Keble, R. A., Department of Mines, Melbourne	1911
Kerr, Miss Lesley R., M.Sc., St. Monan's, Bacchus Marsh.	1922
Knott, J. E., State Rivers and Water Commission, Ouyen, Victoria.	1923
Lambert, C. A., Bank of N.S.W., Melbourne	1919
Leslie, J. R., 99 Toorak-road, South Yarra	1923
Lewis, Miss R. M., 52 Campbell-road, East Kew. ...	1925
Limborn, R. M., 98 Highett-street, W. Richmond. ...	1924
Long, Miss M. E., Physiology School, University, Carlton.	1924
Luher, R. E., B.A., 101 Hickford-street, E. Brunswick	1919
Luly, W. H., Department of Lands, Public Offices, Melb.	1896
Macdonald, B. E., Meteorological Bureau, Melbourne	1920
Mackenzie, G., 1 High-street, Prahran	1907

Macleay, C. W., 56 Cole-street, Elsternwick	1879
McInerny, Miss K., M.Sc., Geology School, University, Carlton.	1918
McLennan, Ethel, D.Sc., Botany School, University, Carlton.	1915
Melhuish, T. D'A., M.Sc., Port Pirie, South Australia	1919
Moore, F. E., O.B.E., Chief Electrical Engineer's Branch, P.M.G's. Dept., Treasury Gardens, Melbourne.	1920
Morris, P. F., National Herbarium, S. Yarra	1922
Nelson, Miss E. A., M.A., M.Sc., University, Carlton.	1924
Nicholson, Miss Margaret G., 59 Murray-street, El- sternwick.	1920
Oke, C., 56 Chaucer-street, St. Kilda.	1922
Pern, Dr. Sydney, M.R.C.S., L.R.C.P., 16 Collins- street, Melbourne.	1920
Petersen, Miss K., B.Sc., 56 Berkeley-street, Hawthorn	1919
Pitman, E. J. G., M.A., B.Sc., Ormond College, Park- ville.	1924
Pretty, R. B., M.Sc., 99 Primrose-street, Essendon ...	1922
Raff, Miss J. W., M.Sc., F.E.S., University, Carlton ...	1910
Richardson, Sidney C., 21 Whitehall-street, Footscray	1923
Rosenthal, Newman H., 49 Odessa-street, St. Kilda ...	1921
Ross, Miss D. J., M.Sc., Merton Hall, Anderson-street, South Yarra.	1924
Rossiter, Captain A. L., M.Sc., Melbourne High School, Victoria-street, Melbourne.	1913
Salier, D. G., Queen's College, Carlton	1924
Sayce, E. L., Research Laboratories, Maribyrnong ...	1924
Scott, T. F., M.A., High School, Shepparton	1917
Sharman, P. J., M.Sc., "Glenalvie," 9 Daphne-street, Canterbury.	1916
Shearer, J., B.Sc., Queen's College, Carlton	1924
Showers, Alan, F., B.Sc., Brewster-street, Essendon ...	1922
Sinclair, J. Malcolm, 700 Burwood-road, Auburn	1924
Singleton, F. A., M.Sc., Geology School, University, Carlton.	1917
Smith, J. A., 25 Collins-place, Melbourne	1905
Stickland, John, 433 Brunswick-street, Fitzroy	1922
Stillman, Miss E. G., B.Sc., "Taiyuan," 5 Grange- road, Kew.	1919
Stillwell, F. L., D.Sc., 44 Elphin-grove, Hawthorn ...	1910
Sutton, C. S., M.B., B.S., Rathdown-street, N. Carlton	1908
Tattam, C. M., M.Sc., 1 Miller-street, Essendon	1924
Thomas, R. G., B.Ag.Sc., State Farm, Rutherglen, Victoria.	1922

Thompson, Mrs. G. R., 26 Fawkner-street, St. Kilda	1922
Thorn, Wm., Christobel-crescent, Hawthorn	1907
Traill, J. C., B.A., B.C.E., "Myoora," Toorak-road, Toorak.	1903
Treloar, H. M., Meteorological Bureau, Melbourne ...	1922
Trüdinger, W., Gerald-street, Murrumbeena	1918
Williamson, H. B., F.L.S., "The Grange," Corner Waverley-road, East Caulfield.	1919
Wilson, F. E., 22 Ferncroft-avenue, E. Malvern	1921
Wilson, Major H. W., O.B.E., M.C., C.de G., B.Sc., 630 Inkerman-road Caulfield.	1923
Woodward, J. H., Queen's Buildings, No. 1 Rathdown- street, Carlton.	1903

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ART. I.—*Contributions to the Flora of Australia, No. 32.**
Additions to the Flora of the Northern Territory.

By A. J. EWART, D.Sc., Ph.D., F.L.S., F.R.S., and
LESLEY R. KERR, M.Sc.

[Read 11th March, 1926.]

GRAMINEAE.

Ectrosia agrostoides Benth.

Batchelor, N.T., and near Darwin, N.T., 26/7/11, No. 104, G. F. Hill. This was recorded as *Triraphis mollis*, in the Northern Territory Flora. It is probably often confused with this species or with *Ectrosia leporina*, and is probably more widely distributed than would appear from the records.

Ectrosia spadicea R.Br.

Thring Swamp, Wycliffe, N.T., June, 1924; from the Herbert River to Carpentaria, 1886, Lieut. Dittrich; Gilbert River, Queensland, Armit, No. 902.

This is closer to *E. agrostoides* than to *E. leporina*.

EUPHORBIACEAE.

EUPHORBIA PETALA, n. sp.

Wycliffe Well, June, 1924, A.J.E.

A small prostrate herb with a central deeply descending tap root and slender spreading branches a few inches in length; leaves on very short stalks, mostly opposite, with an oblique base and broadly oblong; flowers crowded at the ends of the branches, axillary or terminal, with prominent pink appendages resembling petals; glands prominent, appendages of the involucre with a fringed border, the stalk of the ovary projecting well beyond the "flower," sterile hairs between the stamens (male flowers), the stalk of each stamen prominently jointed near the tip, seeds smooth, style very short, not deeply bifid.

The plant shows affinities to *E. filipes*, *E. myrtoides*, *E. Drummondii* and *E. alsiniflora*. *E. filipes* is a much taller, diffusely erect plant, and has a much longer and more deeply bifid stigma. *E. myrtoides* has an erect habit, larger leaves, and only very small petal-like appendages. *E. petala* differs from *E. Drummondii* in having smooth, not rugose, seeds, and in having petal-like appendages as in *E. alsiniflora*. It has, however, the habit of *E. Drummondii*, and differs from *E. alsiniflora* in having smaller glands, and the petal-like appendages relatively much larger.

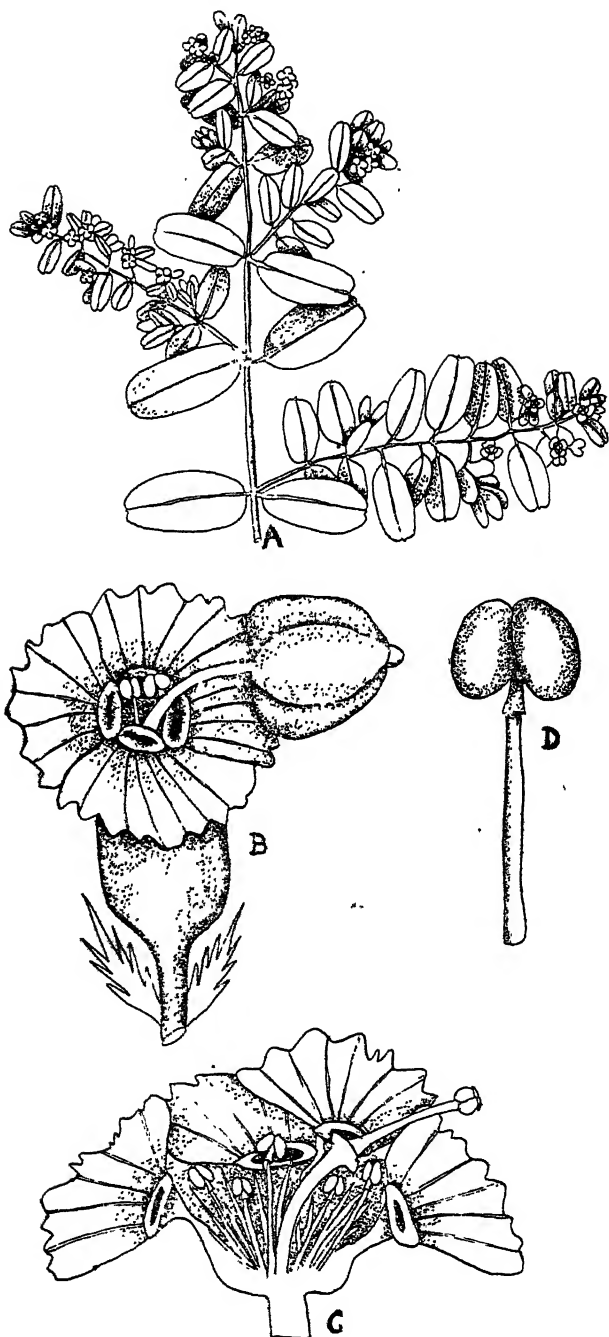


Fig. 1—*Euphorbia petala*, n. sp.

A, Portion of flowering shoot; B, single inflorescence enlarged, showing the petaloid rays to the involucre glands; C, the same in vertical section, showing the male flowers with their appendages and the stalked central female flower; D, single male flower.

PAPILIONACEAE.

INDIGOFERA UNCINATA, n. sp.

A slender attenuated shrub of almost tree-like habit and 6 to 8 feet in height; leaflets paler beneath, covered with small whitish appressed hairs, usually seven leaflets, lanceolate or elliptical; stipules forming small pointed thorns; flowers axillary, clustered at the ends of the racemes, buds with a rusty tomentum. The racemes open out in fruit; corolla dark purplish red and caducous, usually only one flower showing at a time in each raceme, pod linear an inch or rather more in length, thick with the dorsal and ventral sutures prominent, the surface hairy and with pithy partitions between the rather large seeds. The hairs rub off the ripe pods readily.

This plant appears to be the same as that placed by Benthams as *Indigofera brevidens* var. *uncinata*. There is also a variety *uncinata* of *I. australis* in the Tate Herbarium (Wirrabirie, R. Brown, Oct., 1882), which has curved thorny stipules, but has the more numerous leaflets and flowers of *I. australis*. The flowers of *I. australis* are purple to pale fuchsia in colour, whereas this plant has more darkly red flowers. It is intermediate between *I. australis* and *I. brevidens*, but is less whitish hoary than the latter, has the characteristic thorny stipules, has smaller flowers than both species, is taller than either, with a woody stem, and is almost like a small attenuated tree 6 to 8 feet high.

Forrest expedition, 1874 (without locality); towards Alice Springs, Flint, 1882; Gawler Ranges, R. F. Sullivan; Camp 17, S. Australia, R. Helms (Elder expl. exped.), 1891; Tarella, W. Bauerlen, No. 116, 1887; Cobar, N.S.W., J. M. Curran, 1887; Mt. Watson, near Birkgate River, R. Helms; Taylor Range, N.T., A. J. E., June, 1924. One doubtful specimen without locality (ex. Herb. Melb., Dr. Mueller, Jan., 1853), which was seen by Benthams, has the thorny stipules less developed, but has the smaller flowers and taller shrubby habit of *I. uncinata*. The legumes are, however, shorter and glabrous.

INDIGOFERA UNCINATA, n. sp., var. MINOR.

Hastings River, Dr. Beckler; Barrier Range, Dr. Beckler, 1861; Gascoyne River, W.A., J. Forrest, 1882.

This plant was placed under *I. australis*, as variety *minor* by Benthams. It represents a further divergence from the *australis* type. The hairiness of the leaves is more prominent, the leaflets are five in number and smaller, the stipules are spiny but smaller, the whole plant is very woody, and the stem notched.



Fig. 2—*Indigofera uncinata*, n. sp.

PTYCHOSEMA TRIFOLIATUM F.v.M.

This interesting plant, whose yellow flowers and trifoliate leaves at a distance give it the appearance of a creeping *Lotus*, was described from imperfect non-fruiting material by Mueller in Wing's *Southern Science Record*, 1882, ii., p. 72. It is already recorded from Central Australia, but as abundant material was obtained in the bed of the Hansen River, near Central Mt. Stuart, by the senior author in 1924, a full description and figure of the plant is given.

A slender attenuated herb with a deeply descending tap root and slender prostrate spreading branches one to two feet in length, and trifoliate leaves on long, slender leaf stalks, the leaflets small, bi-lobed and obovate, glabrous and non-glandular. Stipules lanceolate, small but prominent. Flowers solitary, on long stalks, leaf opposed. Sepals five, the three anterior sepals united half-way up, the tube campanulate, the lobes bluntly pointed, the two posterior sepals united nearly to their tips.

Standard yellow, with a spot at the throat of the flower, about as broad as long, with two rounded lobes narrowing to a stalk, the whole about as long as the carina. Alae yellow, on slender stalks, small, narrow, somewhat spathulate, and about half the length of the carina. Carina a paler greenish yellow, with small purplish spots or veins outside (as also on the outside of the vexillum), the petals united near the tip by their ventral edges and with free projecting terminal lobes. Stamens ten, all loosely united nearly half way up, the sheath split posteriorly, and persisting at the base of the pod. Anthers versatile, two celled, oblong. Style long, slender, tapering and glabrous. Stigma very small, but terminal and capitate. Ovary prominently stalked, ten to twelve ovules. Fruit flat, about 20 mm. long by 4 mm. broad, the valves pale and thin, with usually 6 to 8 rounded-oblong seeds on long laterally inserted stalks, radicle short but bent.

The genus *Ptychosema* was based by Bentham upon a non-fruiting specimen of *P. pusillum*, from W. Australia, and this is the only species described in Bentham's Flora. Since then Mueller described two additional species, *P. anomalum* and *P. trifoliatum*, the first species having pinnate foliage, the last-named trifoliate. The two first species appear to be very rare, whereas *P. trifoliatum* extends in various localities from the Northern Territory to W. Australia, mostly in sandy flats near soaks, or in river beds. The ovary is not sessile, but stalked; the carinal petals are only partially united, all the petals have prominent stalks, the anthers are versatile, and the radicle is short but curved. *Lamprolobium* is closely allied, but has a short but quite straight radicle. Bentham placed both genera in the Galegae next to *Tephrosia*, mainly on account of their pinnate foliage, and Engler's Pflanzenfamilien adopts the same systematic position. *P. trifoliatum* has, however, the foliage of the

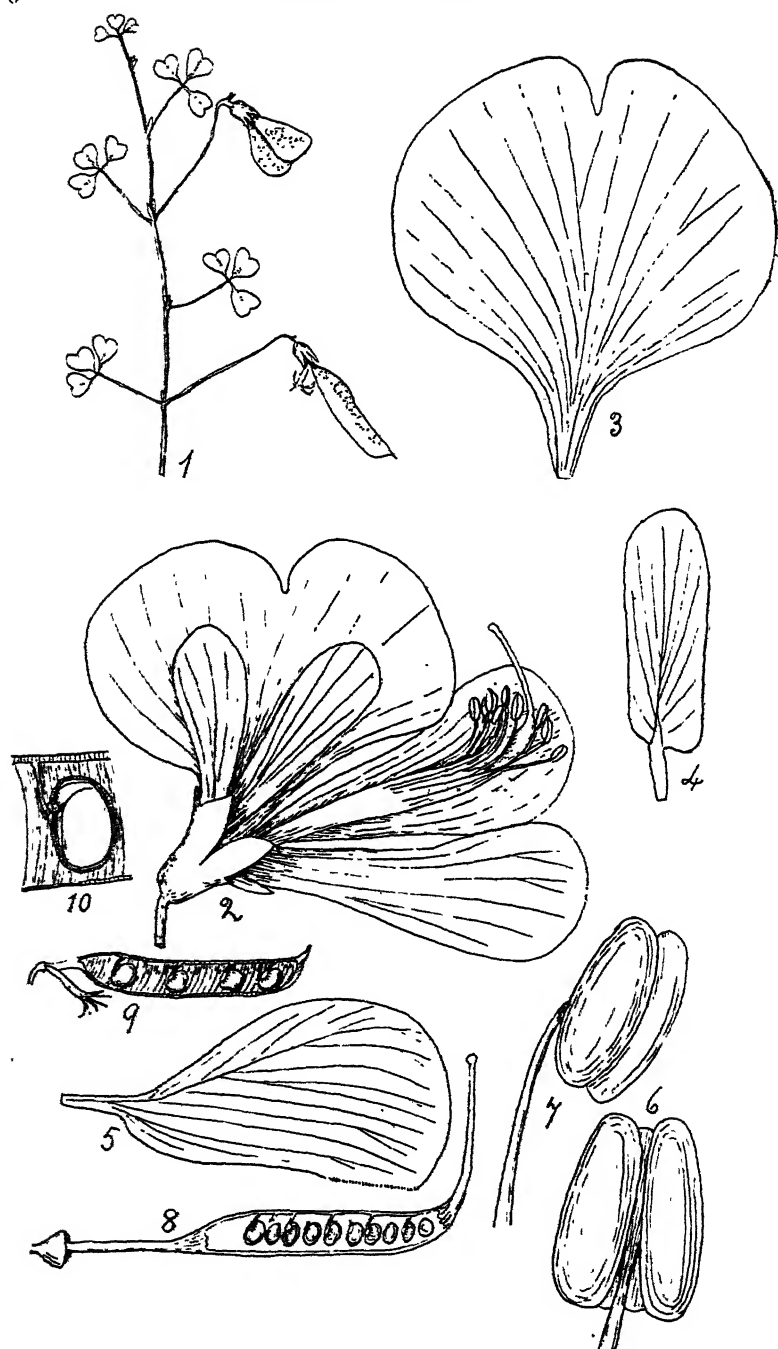


Fig. 3—*Ptychosema trifoliatum*, F. v. M.

1, Tip of a branch, with flowers, fruit and leaves; 2, flower, with the carina pulled down and opened out; 3, standard; 4, ala; 5, carinal petal; 6, stamen from the back; and 7, from the side; 8, young ovary enlarged and side removed; 9, fruit $1\frac{1}{2}$ times natural size, one valve removed; 10, portion of valve with a single seed, half of the seed coat removed.

Genistae, and the split staminal sheath and general structure of the flower in all the species undoubtedly justifies the transference of both genera from the Galegae to the Genistae, placing them between *Rothia* and *Goodia*.

MYRTACEAE.

EUCALYPTUS GILLENI, n. sp.

Mt. Gillen, N.T., July, 1924; A.J.E.

A low, densely-branched shrub, spreading from the base, about 6 to 8 feet high, with a smooth bark on the branches, becoming rougher and more box-like on the older stems, but not fibrous. Leaves shortly stalked with the petiole usually twisted so as to place the lamina vertical, linear-ovate to lanceolate, bluntly pointed, thick, very coriaceous, pale green on both sides, intramarginal vein prominently developed, and frequently with a second fainter intramarginal vein nearer the edge of the leaf; lateral veins diverging at an angle of about 45°; young shoots angular, mid-rib red. Fruits shortly stalked, usually in clusters of three, occasionally in twos, or even single, and either on terminal leafless branches or on leafy shoots opposite the leaves or in their axils, peduncles short, thick and more or less angular; capsules sessile almost globular, with an equatorial rim and a dome-shaped top with four, or less commonly three, short valves with flattened incurved tips; seeds not winged.

The fruit somewhat resembles that of *E. macrorrhyncha*, but the bark is quite different. The nearest affinity appears to be *E. Oldfieldii*, but the general habit and the short angular common pedicel are distinctive features. Although the flowers have not been seen, the species appears to be quite distinct.

Juvenile leaves narrow, ovate lanceolate, pointed, shortly stalked, opposite and becoming alternate later; venation almost identical with the adult leaves, except that the intramarginal vein is thinner and single and the leaves less coriaceous than the adult; oil glands not numerous, but more prominent on the juvenile foliage. The plant is strongly xerophytic, and only grows so far as is known on the southern slope of Mt. Gillen, among tufts of porcupine grass. It grows well in Melbourne, forming a rather graceful small shrub, but seems reluctant to flower.

GOODENIACEAE.

VELLEIA PROSTRATA, n. sp.

Wycliffe Well, June, 1924, A.J.E.

A small prostrate herb arising from a short thick root-stock, with slender straggling branches up to 18 inches in length, or even more. Leaves opposite, lanceolate, narrowing at the base, but without a distinct petiole. At each leaf axil and in the forks of the branches are tufts of whitish hairs. Inflorescence, a loose



Fig. 4—*Eucalyptus gilleni*, n. sp.

1, Adult leaves with double intramarginal vein and axillary fruits; 2, juvenile leaves; 3, fruiting branch, the leaves fallen.

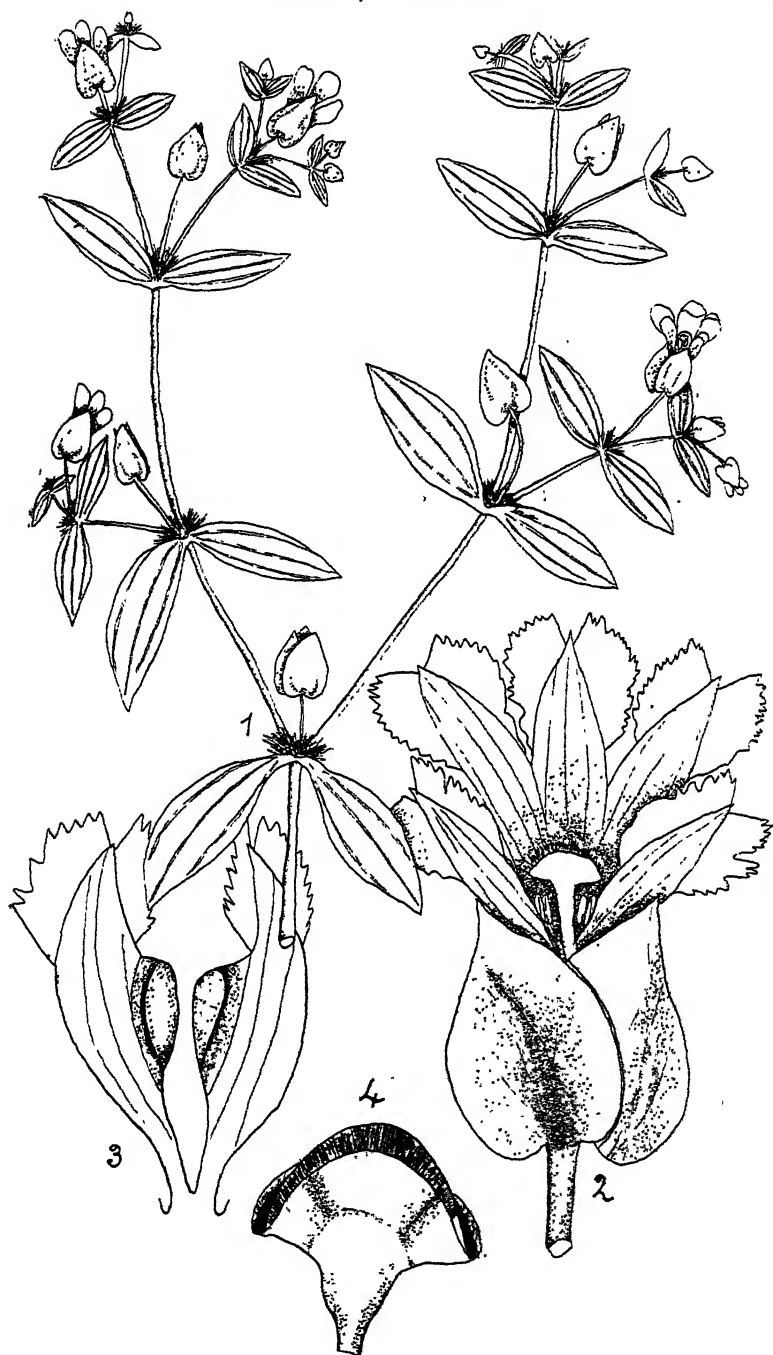


Fig. 5—*Velleia prostrata*, n. sp.

1, Flowering branch with leaves; 2, flower enlarged; 3, the two posterior petals showing frilled appendages and lateral auricles; 4, top of the style with folded indusium.

dichasium, with large, leafy bracts, and one or two flowers in the final forks. Flowers yellow, the calyx of three sepals coherent by their edges for more than two-thirds of their length, and separating as the fruit opens; corolla yellow, the three anterior petals longer than the posterior, the free lobes equal, with fringed bilateral appendages, and projecting beyond the calyx. The two posterior petals are free almost to their bases, the inner edges at the middle have each an auriculate appendage curled around the stigma, the terminal portion has membranous appendages similar to the other petals. Stamens 5, anthers free. Ovary superior, the dissepiment extending more than half way up. Seeds at least 17, small, thick, with a tubercular surface, and a narrow border. Indusium cup-shaped, with prominently hairy lips, closing when the flower opens and folding horseshoe fashion.

The nearest affinity is *V. perfoliata*, but the posterior petals are winged on both sides and the bracts are barely connate.

**Additions or new localities from the Tate Herbarium,
Adelaide, University.**

The following are not given in the Flora of the Northern Territory, Ewart and Davies, or in the Horn Expedition Botany, R. Tate, 1896. The collector is R. Tate, if no name is given.

MONOCOTYLEDONEAE.

GRAMINEAE.

Eriachne obtusa R.Br.

Newcastle Waters and Fitzroy River, Calvert Exp., 1894.

Astrelia pectinata F.v.M.

Swallow Creek, 1894.

A. triticoides, F.v.M. var. *lappacea*.

Newcastle Waters.

Chloris barbata Sw.

Tennant's Creek and Barrow Creek, 1894.

Cynodon tenellus R.Br.

Fitzroy River, Calvert Exp., 1897.

Andropogon intermedius, R.Br.

Finke River, at Crown Point, 1894.

Perotis latifolia Ait. (*P. rara* R.Br.).

Newcastle Waters, Tennant's Creek, Barrow Creek, 1894; also Rev. Kempe, Finke River, 1882. This genus is given in Engler's Pflanzenfamilien as from the Old World tropics, and in the Kew Index from India, East Africa, Japan and Cuba.

Imperata arundinacea Cyr.

Illamurta Marsh, 1894.

Leptochloa subdigitata Trin.

Horseshoe Bend, 1894.

Elytrophorus articulatus Beauv.

Arnhems Land, F.v.M. This species is given in the Kew Index as from the E. Indies, and by Engler as from the whole of the Old World tropics.

Diplachne fusca Beauv.

Glen Helen Gorge, Finke River, 1894.

Eragrostis diandra Steud.

Pine Creek and Barrow Creek.

E. Dielsii Pilger.

Goyder River, 1894. (This was under the name of *E. falcata* Gaud.)

E. laniflora Benth.

Bagato Creek, R. Tate, 1894.

Anthistiria membranacea Lindl.

Swallow Creek, Central Australia, 1894.

Panicum argenteum R.Br.

Near MacDonnell Ranges, Rev. W. F. Schwartz, 1889 (ex Nat. Herb. Melb.).

P. reversum F.v.M.

Finke River, at Crown Point, 1894.

JUNCAGINACEAE.

Triglochin centrocarpum Hook.

Victoria Springs, Upper Arkaringa Valley, and Mt. Ilbillie, R. Helms, 1891, and Deering Creek, R. Tate (as *T. calcitrapa* Hook.).

NAJADACEAE.

Najas major All.

Palm Creek and Ilara Water, 1894.

CYPERACEAE.

Schoenus hexandrus F.v.M. and Tate.

Vict. Desert, Camp 57, 1891, R. Helms.

Cyperus alterniflorus R.Br. (labelled *C. fulvus* by Tate).

Finke River, at Horseshoe Bend; Glen Helen, 1894. It is doubtful whether *C. fulvus* occurs in the Northern Territory; the nearest recorded locality is one from Charlotte Waters, collected by Giles.

Scirpus lacustris L. (labelled *S. littoralis*).

Ilara Water, 1894.

S. supinus L.

Deering Creek, Central Australia, 1894.

Eleocharis acuta R.Br.

Deering Creek, 1894.

COMMELINACEAE.

Commelina agrostophylla F.v.M.

Pine Creek.

C. ensifolia R.Br.

Barrow Creek.

ORCHIDACEAE.

Dendrobium Foelschei F.v.M. (*D. canaliculatum* R.Br. var.
Foelschei.)

Near Port Darwin, P. Foelsche, 1882.

ART. II.—*New or Little-known Fossils in the National Museum. Part XXX.—A Silurian Jelly-fish.*

By FREDK. CHAPMAN, A.L.S.
(Palaeontologist to the National Museum.)

(With Plates I. and II.)

[Read 8th April, 1926.]

Introduction.

Probably hardly anything in the province of fossil discovery that has come within my ken during the past forty-five years equals in interest and wonder that of a beautifully preserved jelly-fish in the Silurian mudstone of Brunswick, Victoria.

It was at about the same spot, but on a higher horizon of the Silurian, that a marvellously preserved cast of a crinoid, *Helicocrinus plumosus* (1, p. 108, pls. xvii., xviii.) was found twenty-four years previously. Only for the care and interest of the two workmen who found these respective fossils are we able to include them among the treasures of the National Museum.

Description of the Fossil.

Class HYDROZOA.

Sub-Class SCYPHOMEDUSAE.

Order DISCOPHORA.

Genus *Discophyllum*, J. Hall, 1847.

DISCOPHYLLUM MIRABILE, sp. nov.

(Plates I. and II.)

The Holotype.

The circular form of the umbrella is distinctly shown, and only a little distorted by pressure. The diameter of this portion is 118 mm. The total probable diameter, including the tentacles, is 168 mm., or about 6½ inches.

The radials of the umbrella are seen as perfect ridges in the fossil, and therefore there has been the least amount of compression compatible with its preservation. The number of radial

ridges on the umbrella is about 56. These are rounded to roundly depressed, and are crossed by strong, concentric ridges that bear a composite undulate ornament. The frilled ribs extend practically to the centre of the umbrella.

Where the external covering has been broken through, or is thin, there are seen the four gastro-genital pouches arranged in a cruciform manner just as in a modern *Aurellia*.¹ These pouches are more or less cuspidate in outline.

The tentacles are seen as a zone of delicate, threadlike, carbonaceous stains surrounding the umbrella, and appear to become more visible in a photograph. They are of two kinds, those which emanate from the termination of the ribs are strong, and seem to be grooved, whilst the interspace is filled in with multitudes of finer tentacles. The tentacles extend beyond the umbrella margin for about 25 mm.

The central part of the disc was apparently more strongly convex, so that the central diameter, of about 64 mm., is marked off as with a depressed ring. It is within this central zone that the pouches are confined. The concentric ridges are seen to interdigitate on the sides of the radials, so that there is left in the radial furrow a lenticular pit. This arrangement imparts a beautiful undulose ornamentation to the umbrella surface.

Note on the Paratype.

It was fortunate that the counterpart of the fossil was also secured (purchased by Mr. F. A. Cudmore), for this gives some details not seen in the holotype; and we are indebted to Mr. Cudmore for the loan of this specimen.

The central part of the disc in the paratype is perfectly shown by a fine impression of the radials emanating from a clear apical spot in the centre. This apical spot has a diameter of 4 mm. The surrounding ring of radials is very delicate, and the striate ridges, at a diameter of 11 mm., bifurcate into the stronger ridges that pass over the general area of the disc.

Towards one side of the paratype there appears to be distinct evidence of the impression of the manubrium. This is represented by a pendent cluster of divergent and crenulated ridges, which suggest a depressed tubular structure lying within the central disc.

Relationship of the Fossil.

So far, I have been unable to find more than one other described jelly-fish which can be compared with the present specimen. It is the *Discophyllum peltatum* of James Hall (2, p. 277, pl. lxxv., fig. 3). The resemblance of this species is so close to the Victorian specimen that it is clearly congeneric. Hall's species

1.—Usually referred to as *Aurella*, Agassiz, 1862. . Correctly as *Aurellia*, Peron and Lesueur, 1809.

was found in the Trenton Series at Troy, New York State. When described, James Hall placed it with the corals. Scudder, in his Index, referred it to the graptolites (3). Later on, Dr. Chas. D. Walcott included it in his fine Monograph on "Fossil Medusae" (4, p. 101, pl. xlvii., figs. 1, 2), and not only replaced the original figure by a better, but figured an additional example from the same locality. These figures leave no shadow of a doubt that they and the Australian specimens are similar in every morphological particular, so far as the genus goes.

In re-describing the Trenton specimen, Dr. Walcott says (4, p. 101): "It is exceedingly difficult to determine whether *D. peltatum* is the impression of a medusa. There is no *a priori* reason why a gelatinous disc should not leave such an impression in the very fine arenaceous silt which now forms the slightly gritty layers embedded in the shales carrying the graptolitic fauna referred to the Trenton terrane. If *D. peltatum* be considered to be the cast of the impression of a medusa, it might be grouped with *Medusina princeps* as an acraspedote medusa."

The close affinities of the Victorian and American species leave little doubt that they both belong to the fringed Scyphozoa, but that the tenuity of the marginal tentacles accounts for their absence in the American specimens, which were preserved in a fine sandy matrix; whereas the Victorian occurs in an impalpable, blue mudstone.

Dr. C. D. Walcott has figured a second specimen of James Hall's species (*Discophyllum peltatum*), and this shows more of the distinctive characters than the original type. There are about 72 radial ridges as against 56 in the Victorian fossil, and they bear a similar ornamentation to each other. As in the Victorian fossil, the Troy specimen shows a distinct central area, although perhaps not so much in relief; it does not, however, afford any convincing evidence of gastro-genital pouches, although some irregular depressions on both the American specimens may indicate their position.

A. G. Mayer, in his "Medusae of the World" (5), does not refer to Hall's *Discophyllum peltatum*, when listing the fossil jelly-fishes, although he enumerates most of the species which have a claim to such origin. Incidentally we may note, however, that he accepts Walcott's interpretation of Torrell's fossil (*Medusina costata*), from the Lower Cambrian of Esthonia, as a probable *Aurellia*.

Occurrence and Age.

This fossil was found by Mr. R. Evans in the blue mudstone of the Silurian (Melbournian) series at Brunswick, north of Melbourne. It was very fortunate that it fell into the hands of a careful collector like Mr. Evans, who, by the way, had previously brought some very interesting fossils to the National Museum.

The bed in which this fossil was found is near the base of the clay pit, at a depth of about 100 feet. It is an exceedingly fine-grained mudstone, that has proved an ideal matrix for a delicate structure such as this. There is no difficulty, to my mind, why a soft body like a jelly-fish should have been preserved as a cast and impression in relief, for when the fine ooze settled down upon the gelatinous body, the latter would be sufficiently rigid to withstand complete pressure, and the succeeding layers would help to distribute the pressure over and away from that particular point. When once the matrix had been fairly compacted there would be no further compression. A noteworthy feature of the bed in which the fossil was found is its horizontality, or if folded, only in the slightest degree.

A face of the clay-pit shows 26 feet of Tertiary (Kalimnan) sand at the top, below which is the Silurian brown mudstone for about 45 feet. Beneath this, in the deepest part, is about 58 feet of blue mudstone and sandstone. It may be remarked that the upper brown bed is more typically Melbournian, and it is quite possible that the blue bed is one of the lowest zones of the Silurian yet reached. In this pit the stratification is almost horizontal, there being only a slight dip towards the boundary of the excavation, and at one end a dip of about 30°.

Associated Fauna and Flora.

From a more sandy bed near the place where the jelly-fish occurred, there was obtained a beautiful specimen of the seaweed, *Bythotrephes gracilis* J. Hall. A description of this specimen is in course of publication, from the pen of Mr. A. J. Lucas. This well-known authority on algae is convinced of the true algal affinities of the fossil, and says that it differs very little from some forms found at the present day.

In other parts of the more sandy rock in this pit were found the remains of:—

- | | |
|--------------|--|
| Algae. | <i>Bythotrephes gracilis</i> J. Hall sp., and several other algae, not yet determined. |
| Brachiopoda. | <i>Camarotoechia</i> sp.
<i>Nucleospira australis</i> McCoy. |
| Gasteropoda. | <i>Euomphalus</i> sp.
<i>Bellerophon</i> sp.
<i>Conularia</i> sp. |
| Cephalopoda. | ? <i>Endoceras</i> sp.
? <i>Ooceras</i> sp. |
| Trilobita. | <i>Calymene</i> sp.
<i>Encrinurus</i> sp. |



ERRATUM.

PLATE II.

For "Discophllyum" read "Discophyllum."



F.C. photo.

Discophllyum mirabile. Silurian. Victoria.

Circ. nat. size.

REFERENCES.

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2. J. HALL, Palaeontology of New York, i., 1847.
3. S. H. SCUDDER. Nomenclator Zoologicus. *Bull. U.S. Nat. Mus.*, No. 19, 1882.
4. C. D. WALCOTT. Fossil Medusae. *Mon. U.S. Geol. Surv.*, xxx., 1898.
5. A. G. MAYER. Medusae of the World. *Carnegie Inst., Washington, Publ. No. 109*, i.-iii., 1910.

EXPLANATION OF PLATES.

PLATE I.

- Fig. 1.—*Discophyllum mirabile*, sp. nov. Holotype. Silurian. Hoffman's Clay-pit, Brunswick Circ. $\frac{2}{3}$ nat. size.
- Fig. 2.—*D. mirabile*, sp. nov. Paratype. Counterpart of Holotype: Silurian, Brunswick Circ. $\frac{2}{3}$ nat. size.

PLATE II.

D. mirabile, sp. nov. Paratype: Circ. nat. size.

ART III.—*Distorted Pebbles from Goat Island, Tasmania.*

By E. J. DUNN, F.G.S.

(With Plates III.-VI.)

[Read 8th April, 1926.]

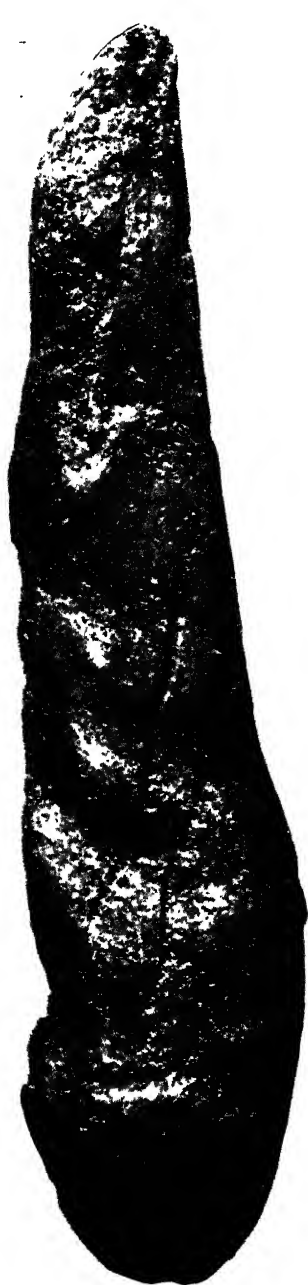
Near Ulverstone, on the North Coast of Tasmania, a small rocky peninsula juts out into the sea. At high water it becomes an island, known as Goat Island.

My attention was first directed to this locality by the late Mr. Twelvetrees, Government Geologist, who sent me a sample of the conglomerate. Since then I have visited the spot, where the conglomerate consists of quartz and quartzite pebbles of moderate size, embedded in a fine micaceous schist base. The only published reference to this locality that has come under my notice is in a paper by the late Mr. Twelvetrees, Government Geologist for Tasmania, entitled *Outlines of the Geology of Tasmania*, in Report of the Secretary for Mines for year 1908, published 1909, p. 118. Under the heading of Pre-Cambrian, locality Ulverstone and Forth, he states: "At the mouth of the River Leven, quartzitic and sericitic schists and schistose conglomerates, with beautifully stretched quartz pebbles, are well exposed along the beach eastward as far as Buttons Rivulet, where they are covered by basalt of Tertiary age, with a general strike of N.10°E.; and westward past Picnic Point to halfway across Barkworth's Bay, west of Goat Island, where their junction with the overlying Dundas and Leven Cambrians is hidden by a flow of lava. The striped slates and breccia a little further west appear with a strike of from N.15° to 25°W., showing their strongly unconformable position on the Algonkian schists. The schistose conglomerates on Goat Island furnish classical examples of dynamically deformed pebble beds, the quartz pebbles being stretched into lenticles and narrow strips without fracture. The strike of the schists west of Goat Island ranges from N.12° to 30°E., with a north-westerly dip."

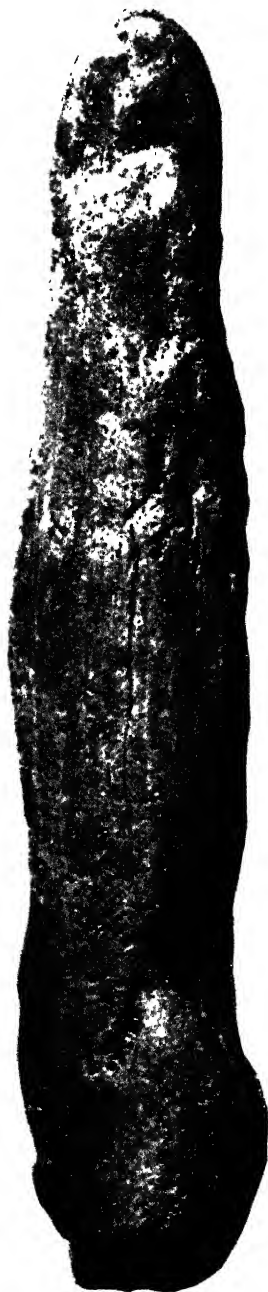
During the period the conglomerate has existed, it has been subjected to all manner of strains and stresses that have left their impress on the pebbles, as shown in the illustrations.

No. 1 is attenuated to probably more than twice its original length. It is flattened as well as elongated, showing that it has been subjected to both tension and compression. Length, 10½ inches; breadth, 2 inches; thickness, ¾ inch.

No. 2 is a cylindrical pebble that has been elongated by tensile forces, but it has not been compressed like No. 1. On each end a small pebble of finer grained quartz is embodied. It was found



1



2



3



4





among some beach pebbles, and has been subjected to wave action since it was detached from its matrix. Length, 11 inches; thickness, 2 inches.

No. 3 is a flattened pebble that has been most affected by compression, and resembles the upper valve of an oyster shell. Length, 5 inches; breadth, $3\frac{1}{2}$ inches; greatest thickness, 1 inch.

No. 4. Like No. 3, this pebble has been most affected by compressive forces. Length, $4\frac{1}{4}$ inches; greatest breadth, $2\frac{1}{2}$ inches; greatest thickness, $\frac{3}{4}$ inch.

No. 5. This pebble does not appear to have suffered much deformation, except that it has been fractured and faulted. The exposed surface is covered with red lichen. Attached to the back of the pebble is fine micaceous schist matrix. Unlike the other pebbles, which are of quartz, this is of quartzite. Length, 6 inches; breadth $2\frac{1}{4}$ inches; thickness, $1\frac{1}{2}$ inch.

No. 6. The feature in this pebble is the remarkable manner in which it has been torn apart. It does not appear to have been lengthened or flattened to any extent, but apparently tensile forces were so applied that fine fractures resulted which have widened out to fissures, the widest of which is about 1 inch. Within the fissures is a growth of small quartz crystals. Besides the actual tearing apart, there has been a little lateral displacement on the opposite sides of the fissures. Length, $5\frac{1}{2}$ inches; width, $2\frac{1}{2}$ inches; thickness, 2 inches.

ART. IV.—*Termites (Isoptera) from South Sea and Torres Strait Islands.*

By GERALD F. HILL.

(Entomologist, National Museum, Melbourne.)

[Read 13th May, 1926.]

The following notes and descriptions refer to a collection of Termites made by Mr. A. M. Lea during his entomological investigations in the South Sea and Torres Strait Islands in 1924.

Of the five species, representing three genera, obtained in Fiji, two are proposed as new, one is referred to a well-known Samoan species, one to a recently described (MS.) species contained in Dr. Buxton's Samoan collection, and one is indeterminable. So far as I am aware, there are no published records of Termites from Fiji. A number of immature *Calotermes* were obtained by Mr. Lea in New Caledonia, from which locality three species have been described previously (Holmgren, 1915). Rennel and Murray Islands, from which no Termites have been recorded previously, yielded one species of *Prorethotermes* and one species of *Microcerotermes* respectively. The former is closely related to, if not identical with, the Samoan species *P. inopinatus* Silv., whilst the latter appears to be conspecific with a North Queensland species, the description of which is in course of publication in *Memoirs of the National Museum, Melbourne*. In each case the material is not sufficiently complete to enable a definite identification to be made.

The types of the new species and examples of the others are in the South Australian Museum; paratypes are in the National Museum, Melbourne.

CALOTERMES (?GLYPTOTERMES) TAVEUNIENSIS, n. sp.

Soldier.

Colour.—Head dark chestnut-brown, mandibles dark ferruginous, labrum, antennae, pronotum and legs buckthorn-brown, frons darker than labrum, but distinctly paler than remainder of head.

Head.—Long and narrow, parallel on the sides, broadly rounded behind; anterodorsal margin, except in middle, slightly elevated, frons concave and sloping to the base of the clypeus at an angle of 45 degrees; anterior one-third of head including frons and clypeus finely shagreened, remainder glabrous, with very scanty moderately large setae. Clypeus large, truncate in

front, anterior half pale in colour, with a row of four setae. Labrum large, extending more than half way to the apex of the mandibles, convex and widest in middle, rounded at apex, with narrow impressed margin and a group of nine to twelve stout setae on anterior half. Antennae short and stout, extending very little beyond apex of mandibles, 10-jointed; 1st joint short and stout; 2nd about half as long as 1st, not much longer than wide; 3rd a little longer than 2nd, and narrower at base; 4th a little longer and stouter than 3rd; 5th to 9th a little longer than 4th and narrower at base, markedly swollen at apex; 10th much shorter and narrower than 9th. Gula long and narrow, with impressed lateral margins, the posterior half parallel-sided, widest part at anterior third, where it is a little less than two-thirds wider than narrowest part.

Pronotum.—Short and wide, as wide as head, broadly concave in front, narrowed slightly on the sides to the broad and faintly sinuate posterior margin, clothed with very scanty setae.

Legs.—Short and comparatively slender, with very few setae; claws small; spurs small and not serrate.

Abdomen.—Long and narrowed to the apex, the tergites with an apical fringe of minute pale setae and with very few long setae elsewhere.

Measurements.—

	mm.
Total length - - - - -	4.90 — 5.10
Head, with mandibles, long - - -	2.22 — 2.33
Head, without mandibles, long - -	1.65 — 1.71
Head, wide - - - - -	0.93
Head, deep - - - - -	0.85
Gula, at narrowest part, wide - -	0.45 — 0.57
Pronotum, long 0.51; wide - - -	0.91 — 0.97
Tibia iii. long - - - - -	0.68

Locality.—Fiji: Taveuni.

Described from three soldiers and several larvae; collected in May.

Allied Species.—Differs from *C. (?G.) perangustus* Hill (1926), *inter alia*, in having a much darker, smaller, and more setaceous head, relatively long and narrow labrum, different frons and reddish mandibles.

CALOTERMES (CALOTERMES) REPANDUS Hill (MS.).

Mem. Nat. Mus. Melb., No. 7 (In Press).

A small colony comprising one dealated imago and several soldiers and workers, from Taveuni, Fiji, agrees very closely with the above species from Samoa. So far as comparison is possible, the imago differs only in its smaller size. The soldiers also agree very closely with the smaller examples of the Samoan species, from which they differ in having the head slightly darker and very little more setaceous, and the antennae 12- to 16-jointed

(13- to 15-jointed in *C. repandus*), As in the latter, some examples have the joints beyond the 5th or 6th relatively shorter and stouter than in others. The 3rd joint is not so well developed as in typical *Calotermes*, s. str., but it is more developed than is the case in any species of the sub-genus *Neotermes* known to the writer. Until more material is available for examination there would appear to be no reason to regard the Fijian insect as being distinct from the Samoan form.

Measurements of soldier—

Head, with mandibles, long - - - -	mm.
Head, without mandibles, long - - - -	4.00
Head, wide - - - -	2.56
Pronotum, long 1.14; wide - - - -	1.71
	1.71

CALOTERMES (CRYPTOTERMES) ? sp.

Two damaged alate imagos from Viti Levu, Fiji (April) are very closely allied to *C. primus* Hill (from Townsville, N.Q.). The specific differences between imagos of the sub-genus *Cryptotermes* with markedly different soldiers are often difficult to detect.

CALOTERMES ? sp.

A series of larvae only from Noumea, New Caledonia, may be referable to one of the three species described by Drs. K. and N. Holmgren, in 1915, namely *C. rouxi*, *C. sarasini* and *C. canalen-sis*.

PRORHINOTERMES ? INOPINATUS Silvestri.

Die Fauna Südwest-Australiens, ii., 1909.

Soldiers and workers from Taveuni, Fiji, appear to be quite typical of the species originally described by Silvestri from Samoa, and more recently recorded from the Ellice Group (Hill, 1926). To the same, or a very closely allied, species also belongs a small colony found in a log on the beach on Rennel Island, Torres Strait. The soldier in this colony agrees with certain small sized examples in colonies collected recently by Dr. P. A. Buxton in the type locality, but the apterous adult king and queen differ from typical forms in their smaller size and paler colour, and in having a few very long setae on the thorax, and conspicuously long setae on each tergite of the abdomen. Until alate imagos are examined it cannot be stated whether these differences are specific or not. The genus comprises thirteen described species, all of which are more or less closely related and confined almost entirely in their distribution to islands within tropical and sub-tropical waters. Apart from the records referred to above, the only other references to the genus in the Australian Region is that of Snyder (1925), who described *P.*

manni and *P. solomonensis* from Santa Cruz Archipelago and Solomon Islands respectively. Both species are described in the soldier caste only, and are evidently closely allied to Silvestri's species. Many additional species or varieties will doubtless be discovered in the South Pacific Islands since their mode of life offers a ready means of dispersal by ocean currents.

EUTERMES OLIDUS, n. sp.

Soldier.

Colour.—Head and antennae hazel, rostrum and anterior half of pronotum chestnut, remainder of thorax and tergites of abdomen buckthorn-brown, legs somewhat paler.

Head.—Moderately short and deep, widest at posterior one-third and very little narrowed to the base of rostrum, the posterior half hemispherical in dorsal aspect, clothed with many rather short and stout reddish setae; rostrum a little less than one-third of the total length of head, wide at base. Antennae 13- or 14-jointed; 1st joint twice as long as wide, cylindrical; 2nd half as long as 1st, slightly narrowed at base; 3rd as long as 2nd but narrower; 4th to 6th equal, longer than 2nd and 3rd, or 3rd and 4th closely fused, the organ then appearing as 13-jointed, with 2nd joint shortest of all; 7th to 10th long and narrow, longer than 6th; 11th to 13th a little shorter than 7th to 10th; 14th as long as 13th, widest in middle, bluntly rounded at apex.

Pronotum.—Small, the anterior half bent up sharply, narrowed and deeply emarginate in the middle, the anterolateral angles narrowed, the sides sloping acutely to the obscurely emarginate posterior margin, the surface clothed moderately densely with long setae, as on abdomen.

Legs.—Of moderate length and stoutness, very setaceous.

Measurements.—

	mm.
Total length - - - - -	3.50 — 4.50
Head, long - - - - -	1.60 — 1.70
Head, wide - - - - -	1.08
Head, deep - - - - -	0.74
Antennae, long - - - - -	1.80
Pronotum, long, 0.25—0.28; wide - -	0.61
Tibia iii, long - - - - -	1.31

Worker.

Colour.—Head tawny-olive, somewhat paler on the sides and with large russet areas above on either side of the frontal suture; frontal and transverse sutures distinct, pale in colour; frons suffused with russet.

Head.—Large, a little longer than wide, widest across the middle, with rather scanty short setae; frons with a distinct impression on either side of the median line about midway between the transverse and clypeofrontal sutures. Postclypeus same

colour as sides of head, small, about twice as wide as long, strongly convex, without distinct median suture, with three large and many minute setae on each side, the hindermost in the middle, the anteriormost in the anterolateral corner, and the third and smallest close to the latter on the inner side; anteclypeus nearly as long as postclypeus, markedly lengthened in the middle, a dark castaneous spot at the articulation of the mandibles. Labrum small, narrowest at base, widening to the anterior one-fourth, broadly rounded in front. Antennae 15-jointed; 1st and 2nd joints as in soldier; 3rd shortest and narrowest of all; 4th a little longer and wider than 5th; 3rd-6th usually more or less fused.

Pronotum.—As in soldier excepting that it is of uniform colour.

Legs.—Moderately long and slender.

Abdomen.—Large, moderately setaceous.

Measurements.—

Total length	-	-	-	-	-	-	-	mm.
Head, to apex of labrum, long	-	-	-	-	-	-	-	6.00
Head, to clypeofrontal suture, long	-	-	-	-	-	-	-	1.82
Head, wide	-	-	-	-	-	-	-	1.08
Antennae, long	-	-	-	-	-	-	-	1.53
Pronotum, long, 0.45; wide	-	-	-	-	-	-	-	1.70
Tibia iii, long	-	-	-	-	-	-	-	0.80
								1.60

Locality.—Fiji: Taveuni. Lea's No. 20844.

Allied Species.—The soldier appears to resemble most closely the Northern Territory species *E. longipennis* Hill, from which it is easily distinguished by its shorter rostrum, more setaceous head, thorax and body, longer 3rd antennal joint and deeply emarginate pronotum.

MICROCEROTERMES ? TAYLORI Hill (MS.).

Mem. Nat. Mus., Melb., No. 7 (in Press).

A few soldiers and workers of a small species of *Microcerotermes*, from Murray Island, Torres Strait, agree very closely with the above species (from North Queensland). Imagos are required for confirmation of this identification.

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ART. V.—*New Australian Coleoptera, with Notes on some previously described Species, Part III.*

By F. ERASMUS WILSON.

[Read 8th July, 1926.]

PSELAPHIDAE.

SCHISTODACTYLUS GRACILIS, n. sp.

♂ Flavous, in parts infuscated, this noticeably so on second, third, and apex of first dorsal segments of abdomen, and on the whole of undersurface, and less so on the three subapical segments of antennae; very sparsely clothed with a minute depressed pubescence.

Head subquadrate, with large, round, shallow punctures, evenly distributed, except on vertex and portion of base, where they become sparser and less clearly defined; with two small interocular foveae. Antennae with joint 1 cylindric, about equal to 2 and 3 combined, 2-8 gradually decreasing in length, 8 lightly transverse, 9 longer and much wider than 8, 10 strongly transverse, shorter than 9, 11 subovate, almost equal to the three preceding combined. Maxillary palpi with last segment furnished at apex with a spine and a shorter seta, together with a few fine hairs; sub-basal segment with spines of equal length. Prothorax about as long as wide, greatest width about apical third, thence gently rounded to base; puncturation as on head. Elytra strongly transverse, a little longer than prothorax, and with similar puncturation, but not so well defined; sutural striae entire, dorsal disappearing about middle, each arising in minute basal foveae. Abdomen about twice length of elytra, widest at apex of the large segment, at the base of this with a short longitudinal sulcus on each side. Metasternum lightly depressed, punctate. Prosternum with a small conical tubercule on either side, these surmounted with a long sharp seta. Anterior trochanters in middle, and anterior femora near base, armed with a long setigerous spine. Undersurface of abdomen lightly flattened along middle, subapical segment not interrupted in middle, apical segment with a fairly deep round fovea on its apical half.

Length, 1.75 mm.

♀ Similar, but without the abdominal fovea.

Habitat.—South Australia; Myponga (A. H. Elston). Sieved from moss.

This species is most closely allied to *foveiventris* Wilson (1, p. 124). It is however shorter, more slender, and lighter in colour, whilst its puncturation is a little more sparse, and much less

coarse. It differs also in the conformation of the undersurface of its abdomen. In *foveiventris* the subapical segment only appears as a triangle on either side of the fovea, which is very large and cavernous. In *gracilis* the subapical segment is not interrupted in middle, and the fovea is much smaller and confined to the posterior half of the apical segment.

From *armipectus* Wilson (1, p. 123), it differs in its much more slender build (greatest width of *armipectus* 1 mm. and of *gracilis* 0.75 mm.), in its head not being impressed in front, in its more sparse, and much less coarse puncturation, in its shorter and more sparse clothing, and in its abdominal fovea being round and deep.

On the type specimen there are protruding two flattened claspers or forceps, very similar in form to those found in *Psolidura impressa* Boisd. of the Curculionidae.

In *Proc. Roy. Soc. Vic.*, n.s., xxxv. (2), p. 125, I commented upon the fact that each of the four described species of this genus had its habitat in a different State. The addition of this new insect from South Australia fills another gap, and leaves only Queensland without its representative. As, however, that State has up to the present been very imperfectly prospected for Pselaphidae, it is possible that a member of the genus may yet be discovered there.

Type in author's collection. Co-types in Elston's Collection.

NARCODES TERMITOPHILUS, n. sp.

♂ Dark castaneous, but mottled in appearance, due to the bicolouration of clothing; legs and antennae a little lighter; palpi lightly ferrugineous; clothing dense, squamose mostly cream-coloured, but in places notably prothorax, blackish, this clothing becoming more subsquamose on first two or three joints of antennae, the other joints of which are furnished with somewhat short semidecumbent hairs.

Head lightly transverse, with disc raised, and precipitous sides, these from region of eyes to base becoming widely explanate, maximum width across base of eyes, where there is a rounded projection on the lateral border, sides behind projection gently arcuate to base, in front much constricted, and gently decreasing in width to apex; with a wide depression between antennal tubercles and two large shallow interocular foveae; with dense and somewhat coarse puncturation much concealed by clothing. Antennae thin, passing intermediate coxae, basal joint moderately stout, subcylindric, 2 oval, much shorter, 3-7 elongate, 3 nearly twice as long as 2, and a little longer than 4; 4, 5 and 7 subequal, 6 a little shorter, 8 about one half as long as 7, 9 equal in length to 8 but wider, 10 about as long as wide, 11 subovate, as long as the two preceding; the last three segments forming a somewhat inconspicuous club; palpi with joint 4 inserted near summit of swollen portion of joint 3. Prothorax, including lateral projec-

tions, about as wide as long, sides furnished at about apical fourth with a tubercular projection or tooth; from middle to base gently arcuate; with a shallow medio-basal impression, and puncturation as on head. Elytra short, about one-third wider than long, sides evenly rounded, apical margin of each elytron lightly produced near outer angle; dorsal striae widened basally and traceable to about apical fourth; with two somewhat prominent eminences near humeral angles; surface densely and rather coarsely nodular. Abdomen much wider than elytra, first and second segments widened posteriorly, third parallel sided, others decreasing in width, beyond second strongly declivous, surface much as on prothorax. Undersurface densely punctate. Metasternum raised and widely and somewhat deeply excavated. Abdominal segments only slightly flattened. Legs moderately long. Anterior trochanters armed in front with a somewhat flattened protuberance, this at its summit, bluntly dentate exteriorly. Anterior femora each with a minute tubercle near base. All tibiae curved apically.

Length, 4 mm.

♀ Differs in being much larger (4.5 mm.), and in having the undersurface of abdomen a little more convex.

Habitat.—Western Australia; Mundaring (J. Clark). Four males and one female taken in a colony of *Microcerotermes newmani* Hill MS.

This species is the largest of the known *Narcodes*, the only one approaching it in size being *crassus* Oke (2), the measurements given for which are 3.25—3.35 mm. It may, however, be readily differentiated from that species, among other things by its metasternum not being furnished with a lamelliform protuberance and in the undersurface of its abdomen not being excavate.

For the determination of the Termite host of this species I am indebted to my friend Mr. Gerald F. Hill, Entomologist of the National Museum, Melbourne.

Type in Author's collection.

NARCODES GRAMENICOLA, n. sp.

♂ Dark castaneous, prothorax, abdomen in parts, and antennal club, infuscated; palpi flavous; upper surface with clothing moderately dense, squamose, mostly whitish, but in parts fuscous; undersurface with a fairly long whitish adpressed subsquamose vestiture, this noticeably longer at apex of each abdominal segment.

Head including eyes, lightly transverse, raised on disc, with two shallow interocular foveae, and a large median impression in front, extending to front margin; hind angles produced; basal margin arcuate inwardly; with a coarse shallow round puncturation; antennae passing a little intermediate coxae, joint 1 cylindric, viewed from above not much longer than 2, but broader, 3 narrower and longer than 2, 4-7 subcylindric, shorter than 3, 8

much shorter than 7, about as long as broad, 10 strongly transverse, 11 widely and bluntly ovate longer than the two preceding combined. Prothorax transverse, anterior angles produced, posterior wanting, base rounded, sides each with a projection at about apical third, in front and behind these projections lightly arcuate; disc raised; with a shallow medio-basal fovea much obscured by clothing, and an impression on each side; with puncturation as on head. Elytra short, strongly transverse, sides gently rounded, with sutural and discal striae, the latter terminating at about apical third, surface much raised between dorsal and sutural striae, and with a prominent eminence near humeral angles; with puncturation much less clearly defined than on prothorax. Abdomen nearly twice as long as elytra; puncturation as on elytra; its ventral surface strongly flattened, and with a wide shallow excavation on ultimate segment. Metasternum widely and deeply excavate, with a prominent lamelliform protuberance immediately behind each intermediate coxa, these protuberances lightly deflected backwards and slightly overhanging the excavation. Anterior trochanters with a flattened projection in front, this bidentate. Legs with femora strongly inflated, but constricted before apex, the anterior ones each with a minute tubercle near base. Tibiae curved, bluntly spurred apically.

Length, 3 mm. (*vis*).

♀ Similar, but with undersurface of abdomen not flattened, metasternum much less strongly impressed, and with no protuberances behind intermediate coxae.

Habitat.—South Australia; Mount Remarkable (F. E. Wilson and A. M. Lea). Sieved from grass tussocks.

The prominent lamelliform projections behind the middle coxae serve to easily distinguish this species from all other described species of the genus. *Crassus* Oke has its metasternum with a lamelliform projection, but in this case it is located between the posterior coxae.

Type in Author's collection.

SCHAUFUSSIA MONA, n. sp.

♂ Dark reddish castaneous, nitid; elytra except at extreme base and tips, and appendages, a little paler; clothed with rather short semidecumbent yellowish pubescence.

Head moderately long, broad, coarsely and frequently punctate, basal angles widely rounded, rather strongly constricted before eyes, vertex in front suddenly declivous, in centre of declivity with a bunch of golden hairs reaching across to antennal tubercle; with three shallow but sharply defined interocular foveae placed just at edge of declivity, the centre one very large, transverse, broadly rounded, the outer ones small, rounded, and each emitting from its centre a long and strong seta, these directed a little forward; antennal tubercle moderately wide at base, strongly elevated and directed a little backwards, its sides notched

about middle, and its apex broadly rounded and almost reaching the level of vertex. Antennae moderately stout, reaching intermediate coxae, joint 1 cylindric, not quite equal to 2 and 3 combined, 2 cylindric, 3 lightly obconic, 4, 5, 6 cylindric, 2-5 subequal in length, 6 a little shorter, 7 quadrate, 8 a little shorter and a little broader than 7, 9, and 10 trapezoidal, longer than 8 and increasing in width, 11 irregularly ovate, truncated at base, bluntly pointed, a little longer than the two preceding combined. Palpi with second joint pedunculate on basal half and strongly swollen on apical half, its swollen portion dilated internally, third joint shorter, not so stout, fourth as long as third but a little narrower, thin at base, lightly dilated internally, and minutely truncated at apex. Prothorax about as long as broad, broader than head, convex, no medio-basal fovea, sides widely rounded, puncturation coarse and frequent. Elytra lightly transverse, sides evenly rounded, gently narrowed to base; dorsal striae feeble, barely attaining middle of elytra; puncturation similar to that on prothorax but not so conspicuous. Abdomen a little narrower than elytra, strongly depressed beyond first dorsal segment, which is longer than the rest, and which exhibits two feeble basal carinules enclosing a little more than a half part of the base, these difficult to see owing to a fringing effect of the pubescence on the elytral tips; puncturation much as on elytra. Metasternum widely and shallowly excavate, and ventral segments of abdomen slightly flattened along middle. Feet elongate. Anterior and intermediate femora a little more robust than posterior, the anterior armed with a small blunt tooth towards their bases. Four front tibiae rather strongly curved, hind almost straight. Anterior trochanters strongly produced over almost their entire width into a subparallel sided, square ended, plate; intermediate trochanters angularly produced.

Length, 2 mm. (*vix*).

♀ Unknown.

Habitat.—Victoria; Warrandyte (F. E. Wilson). Two examples sieved from moss.

Of the two species assigned to the genus *Schaufussia*, viz., *formosa* King (3), and *nasuta* Raff. (4), this insect comes nearest to the latter. From the former it differs in its strongly elevated antennal tubercle, different arrangement of interocular foveae, its very much more uniform, and more sharply defined puncturation, its more dense clothing, its much shorter and less well defined dorsal striae, etc. From the latter among other things, its elevated antennal tubercle, interocular foveae, and differently armed front trochanters, clearly define it.

Type in Author's collection.

PSELAPHUS STRIGOSUS, n. sp.

♂ Head and prothorax very dark castaneous, the rest much paler; very sparsely clothed with pale moderately long pubes-

cence, this on elytra most noticeable at sides, and arranged in lines; elytral tips not fringed.

Head lightly elongate, not much narrower before than behind eyes; median groove not sharply defined, wide and shallow, widely open in front, and somewhat indistinctly carried back to neck; bigibbous and bifoveate between eyes, the foveae small, round, and placed beneath the gibbosities; the whole coarsely longitudinally strigose. Antennae passing a little middle coxae, club moderate. Palpi with fourth joint strongly arcuate, its club a little more than one-third total length of joint. Prothorax about as wide as long, sides lightly arcuate before base and apex; transverse furrow wide, not interrupted in middle and laterally not terminating in a small round fovea; the whole coarsely longitudinally strigose as on head, except behind furrow, where the strigosity is much finer and more or less transverse. Elytra transverse, sides evenly rounded; apex almost straight; suture not raised, with four striae on each elytron, one sutural, two parallel dorsal, and one diverging extra-dorsal; all except sutural terminating at apical declivity. Abdomen with first segment long, longer than the rest combined, and wider than elytra. Prosternum and metasternum more or less strigose. Second ventral segment of abdomen with a shallow longitudinal impression from base to near apex, and metasternum indistinctly impressed on disc. Legs with femora moderately stout, and hind tibiae rather strongly curved near apex.

Length, 2 mm. (*vix*).

♀ Differs in having undersurface of abdomen convex.

Habitat.—South Australia; Myponga (A. H. Elston). Sieved from moss.

This very fine species is one of the prizes obtained by my friend Mr. Elston, who, like myself, had devoted much time to the examination of mosses and tussocks. In all he secured ten examples—three males and seven females.

Its strigose head and prothorax render it one of the most distinct of the genus, as up to the present no other Australian species has been described having similar sculpture. The hairs, particularly on the elytra and abdomen, are strongly curved just before their apices.

Type in Author's collection. Co-types in collection of A. H. Elston.

PSSELAPHUS NIVEICOLA, n. sp.

♂ Nitid, castaneous, palpi paler; sparsely clothed with moderately long, suberect, black, curved hairs; these arranged in lines on the elytra. Disc of metasternum, and base of abdomen ventrally, with short pale fasciculate clothing.

Head elongate, rather strongly attenuate before eyes; median longitudinal groove terminating between eyes, shallow, its sides in front suddenly converging and almost meeting; with two large rounded interocular foveae, these placed close to the hind margin

of each eye; vertex convex; palpi with fourth joint of moderate length, strongly bent, its club somewhat exceeding one-third of its total length. Prothorax as long as broad, equal in length to head, maximum width at middle; transverse furrow except in centre, shallow, strongly interrupted in middle by a carinate sided longitudinal fovea, and terminating at each side in a roundish fovea; these rounded lateral foveae however are each connected with an irregular shallow longitudinal depression reaching back to the base of prothorax. Elytra lightly transverse, rather strongly narrowed to base, humeral angles acute, apical declivity naked and minutely striolate; the whole of base occupied by four deep longitudinal fossae, these becoming more and more shallow as they recede towards apex; inner fossa on each elytron bounded by the raised suture and a sharp-edged flattish-topped carina, occupying position of dorsal stria, outer bounded by this carina and another sharper one, near the lateral margin; outer edge of dorsal carina traceable to just beyond apical declivity, bent. Abdomen very much depressed beyond first segment, this very long, exceeding the rest combined. Metasternum much raised, shallowly excavated on disc, excavation narrowed to base. Second ventral segment of abdomen with a large, oval, longitudinal excavation extending from base to apex. Legs with femora robust, their surface at base beneath, scaly. Tibiae lightly arcuate, swollen on apical halves, each with an indistinct longitudinal channel, and carinate outer edge.

Length, 2.5 mm.

♀ Unknown.

Habitat.—Victoria; Mount Feathertop, altitude 6200 feet. Sieved from tussocks of snow grass kindly collected for me at the summit, by my friend, Mr. Chas. Barrett.

In Raffray's table, *Proc. Linn. Soc. N.S.W.*, xxv. (2), p. 194, this species would be associated with *pilosus* Raff. (5, p. 201), and *longepilosus* Schaufuss (6). From the former it differs amongst other things in its non-tuberculate head, and from the latter, its carinated elytra serve to distinguish it. From *villosus* Lea (7, p. 750), it may be separated by reason of its more sparse clothing, its greater size, and by its median cephalic groove being almost closed in front. From *bryophilus* Lea (7, p. 751), the latter two characters also serve to differentiate it. *Foveiventris* Lea (7, p. 748) is certainly allied to it, but in that insect the clothing is very different.

Type unique, in Author's collection.

PSSELAPHUS METASTERNALIS, n. sp.

♂ Reddish castaneous, palpi slightly paler; somewhat sparsely clothed with moderately long, pale pubescence, this where present on elytra arranged in lines; elytral tips not fringed. Undersurface with a narrow strip of pearly, subsquamose clothing on each side of mesosternum in front, and on base of abdomen; sides of metas-

ternal and abdominal excavations fringed with pubescence, elsewhere more or less sparse.

Head elongate, median channel deep, moderately wide, and terminating between the eyes, where it becomes widened; with two small round interocular foveae. Antennae reaching about middle coxae, all joints elongate, ninth narrowly ovate, tenth wider but a little shorter, and eleventh equal to the two preceding, ovate acuminate. Palpi thin, about equal in length to antennae, fourth joint arcuate, its club a little more than one-third of its total length. Prothorax about as broad as long, greatest width in advance of middle, sides rounded; transverse furrow terminating in a small round fovea at each side, and lightly interrupted in middle by a minute carinate-sided fovea; surface behind furrow smooth. Elytra slightly broader than long, each elytron with a sutural and dorsal stria, these foveate basally. Abdomen wider than elytra. Metasternum with disc widely and deeply impressed from base to apex, this impression narrowed to middle coxae, and having its greatest width about middle, becoming increasingly deepened as it approaches hind coxae. Undersurface of abdomen with first, second, and ultimate segments, longitudinally impressed, impression on second segment widely oval, that on ultimate segment shallow and not very distinct.

Length, 2.3 mm.

♀ Similar but with metasternum convex, though somewhat depressed posteriorly, and with undersurface of abdomen convex.

Habitat.—Victoria; Mount Donna Buang, 4080 feet (F. E. Wilson). From tussocks of snow grass.

This species seems to fall nearest to *crassus* Raff. (5, p. 200). The author of that species does not state the sex of his type, though from the description, it seems probable that it is a female. *Metasternalis*, however, differs from the description of that species in having its head not bigibbose between the eyes, and in the proportional sizes of its antennal joints. From *elongatus* Raff. (5, p. 200), it may be distinguished by its larger size, in having its palpi not nearly straight, and in having the extreme base of its prothorax not minutely reticulated.

Mr. A. M. Lea states in *Proc. Roy. Soc. Vic.*, xxiii., p. 154, that in the male of *tuberculifrons* Raff., the metasternum is impressed, and that the impression is carried over on to the large segment of the abdomen, but the prominent interocular tubercles of that species, apart from anything else, preclude possibility of confusion with *metasternalis*. The metasternal impression of the latter species is indeed pronounced, and no described Australian species approaches it in this respect.

Type in Author's collection.

PSELAPHUS ELSTONI, n. sp.

♀ Reddish castaneous, palpi noticeably paler; uniformly clothed with moderately long pale pubescence; elytral tips fringed

with blackish setae; with an oval patch on each side of mesosternum in front, and a narrow band on extreme base of abdomen dorsally and ventrally, of pale squamose clothing.

Head short and broad, slightly longer than wide; eyes very prominent and placed a little behind middle; median channel somewhat narrow and deep, widened between eyes, and continued back to neck; with two small round interocular foveae placed a little further from eyes than usual. Antennae moderately long, thin, joint 1 stout, wider than 2, which in turn is wider than 3, but of about equal length, 4-8 subequal, 10 a little longer and wider than 9, 11 about one and one-half longer than 10. Palpi not quite so long as antennae, fourth joint lightly arcuate, its club occupying a little more than half its total length. Prothorax of equal length and breadth, greatest width a little in advance of middle, sides lightly arcuate to base and apex; transverse furrow well defined, terminating at each side in a small round fovea, and interrupted in middle by an oval longitudinal sulcus, this carinate at sides, where it intersects the transverse furrow; surface behind transverse furrow smooth. Elytra lightly transverse, sides gently rounded, almost straight across apex, suture very little raised, each elytron with dorsal and sutural striae. Abdomen very little wider than elytra. Metasternum and ventral surface of abdomen strongly convex.

Length, 1.75 mm.

Habitat.—South Australia; Mount Lofty Ranges (A. H. Elston). Two examples taken in ants' nests. Hosts, *Iridomyrmex nitidus* and *Chalcoponera metallicum*.

This species is most closely allied to *mundus* Sharp (8), but differs from the description of that species in the following details. The channel on disc of head is not indistinct, the clothing is certainly not sparse, and the transverse furrow on prothorax is not entire. Otherwise it has much in common with that beetle.

Type in Author's collection.

PSELAPHUS OTWAYENSIS, n. sp.

♀ Reddish castaneous, tarsi and palpi a little paler; clothing consisting of fairly long, pale semi-decumbent pubescence, this sparse, and mostly confined to abdomen and sides of head, and a very short, dense subsquamose pubescence on dorsal and ventral surfaces of abdomen at base, on mesosternum at apex, and on apical declivity of elytra, except at outer edges.

Head rather broad and of moderate length; median channel a little narrowed in front but continuing back to neck, although considerably widened and somewhat interrupted between eyes; with prominent interocular tubercles, these somewhat hollowed out on their internal sides. Eyes prominent, placed centrally. Surface on either side of median excavation between tubercles, and base of head irregularly and shallowly, transversely sulcate. Antennae moderately long, joint 1 viewed from above equal to 2

and 3 combined, 3-8 subequal, a little narrower than 2, 9 and 10 longer and increasingly wider, their combined length equal to 11, which is subovate. Palpi of moderate length, fourth joint strongly curved, its club about equal to one-third of its total length, and furnished with an indistinct longitudinal sulcus. Prothorax very little wider than head including eyes, about as long as wide, maximum breadth in front of middle; transverse sulcus very wide, strongly arcuate and in places deep, lightly interrupted in middle by two minute carinae, and terminating at each side in a small round fovea, these latter situated in a wide sulcus running back to base of prothorax; surface behind transverse sulcus finely reticulate. Elytra wider than long, sides gently rounded from base to apex, sutural and dorsal striae moderately distinct, the latter on about basal third being represented by a broad, lightly raised, flat topped ridge, formed by the backward prolongation of the basal fovea, of which there are two on each elytron. Abdomen length of elytra, strongly depressed beyond first segment. Metasternum strongly convex. Ventral surface of abdomen convex and its second segment longer than the sum of the succeeding ones.

Length, 2.5 mm.

Habitat.—Victoria; Lorne, in moss (F. E. Wilson).

This *Pselaphus* apparently approaches nearest to *tuberculi-ventris* Lea (7, p. 749), and *longifrons* Raff. (9). From the description of the former it may be distinguished by reason of its very evident interocular tubercles, in having its cephalic surface on either side of median excavation sulcate, in its lack of dense white pubescence on apex of prosternum and middle of neck, in its abdomen not being longer than elytra, and in its elytra possessing four basal foveae. From the description of *longifrons* to which it appears most closely allied, it may be differentiated by the different shape of the apical joint of its antenna, in the possession of lateral longitudinal foveae on its prothorax, in its elytra, being not longer than broad, and in having four and not two basal foveae.

Type unique, in Author's collection.

PSSELAPHUS BIARMATUS, n. sp.

♂ Castaneous, feet and palpi paler, with pale, moderately long subdepressed pubescence, this on elytra rather sparse and arranged in lines, on abdomen more frequent and evenly distributed, on prothorax sparse, and mostly confined to the sides; clothing of undersurface shorter, and most conspicuous on sides and apex of metasternal excavation, on sides of the excavation on second segment of abdomen, and where it forms a broad longitudinal line on ultimate segment; base of abdomen ventrally, narrowly clothed with a moderately thick, short sub-squamose vestiture.

Head with median groove wide, dilated towards its termination between eyes; vertex convex and almost same width as apical extremity; eyes placed slightly behind middle; with two somewhat obsolete interocular elevations or tubercles; undersurface, on either side in region of eyes, armed with two strong outwardly deflected spines. Palpi rather long, fourth joint with club occupying about one-third of its total length, first joint armed at apex with a long bluntly pointed spine. Antennae with first joint much wider than second, and about equal in length to second and third combined, second lightly wider than third, all joints longer than wide, apical joint subovate, acuminate. Prothorax lightly longer than wide, widest slightly in advance of middle, with transversal impression well defined and strongly arcuate, this obsoletely interrupted in middle by two minute carinules, and terminating at the sides in a small roundish fovea. Elytra almost as long as wide, apical declivity naked and minutely striolate, dorsal striae strongly bent and terminating at beginning of apical declivity, bordering either side of the dorsal striae particularly on basal half, the elytral surface is somewhat raised thus forming two longitudinal ridges; also on apical half of elytra, midway between dorsal striae and lateral margins there are faint indications of still another stria on each elytron. Metasternum widely and deeply excavate. Abdomen with second ventral segment longitudinally excavate, apical segment with its surface minutely striolate and with an inconspicuous impression near its termination.

Length, 2 mm.

♀ Unknown.

Habitat.—Victoria; Belgrave, in moss (F. E. Wilson). Fern-tree Gully (C. Barrett).

The armature of the undersurface of the head, and of the palpi, render this species by far the most distinct of any *Pselaphus* so far described from Australia.

Some entomologists might consider that this insect by reason of the armature of its palpi, should have a genus to itself, but apart from this matter of armature it is a typical *Pselaphus*, and I do not consider that any good purpose would be served by isolating it.

Type in Author's collection.

PSELAPHUS GEMINATUS Westw.

(Trans. Ent. Soc. Lond., 1856, p. 273, t.16, f.9.)

Habitat.—South Australia; Myponga, in nest of a small ant, *Iridomyrmex* sp. (A. H. Elston).

TYROMORPHUS VICTORIENSIS, n. sp.

♂ Dark reddish brown, but prothorax and joints 7-10 of antennae tinged with black, palpi and eleventh joints of antennae

flavous; with moderately long pale semidecumbent pubescence.

Head, including eyes, about as wide as long, sides behind eyes evenly rounded to base, in front of eyes rather strongly narrowed to apex; somewhat widely-impressed between antennal ridges, and with two small but rather deep interocular foveae; with large round shallow punctures densely and evenly distributed. Antennae reaching about middle coxae. Joint 1, long, cylindric, about equal to 2 and 3 combined, 2 about equal in length to 3 but thicker, 3 to 8 slightly decreasing in length, 9 about twice as long and nearly twice as wide as 8, 10 transverse, 11 subovate, longer than the two preceding combined. Palpi long, second joint much swollen on its apical half, third about one-half length of second, fourth about twice as long as broad, somewhat excavated at base for the reception of third when folded back upon it, and bearing a longitudinal groove bordered by a carinate ridge, this latter only visible from some directions when palpi are extended, apical truncature of segment bearing a seta. Prothorax approximately as long as wide, widest about apical third, wider at base than apex, sides evenly rounded from apex to position of greatest width, thence almost straight to base; with a small round medio-basal fovea, and puncturation as on head. Elytra transverse, fairly convex, shoulders prominent, sutural striae entire, dorsal wide, and deep basally, and traceable to beyond middle; puncturation much less distinct than on prothorax. Abdomen with first and second dorsal segments subequal in width, the latter much shorter than the former, strongly depressed beyond second segment; first segment with a rather inconspicuous longitudinal impression on either side towards lateral border; ventral surface with a wide shallow impression commencing at base of second segment, and continuing to the apex of abdomen, apical segment strongly produced in middle. Metasternum widely and deeply excavate and with a well defined median longitudinal sulcus. Legs moderately long. Intermediate trochanters at base produced into a strong-subtriangular tooth, posterior with a rounded projection or tooth in like location. Femora moderately stout, rather strongly constricted near apex. All tibiae curved from just beyond middle, this much more apparent on hind tibiae.

Length, 3 mm.

♀ Similar, but no armature on trochanters, ventral surface of abdomen convex and not strongly produced apically, and tibiae much less strongly curved.

Habitat.—Victoria; Beaconsfield (F. E. Wilson). Bacchus Marsh (C. Oke). Ferntree Gully (F. E. Wilson and Ejnar Fischer).

This species is fairly abundant and may usually be found beneath logs or stones in damp situations. It bears rather a strong superficial resemblance to *mastersi* MacL. (10), but may be easily distinguished from that species by the possession of armed trochanters. From *flavimanus* Lea (11), it differs by being larger, in its possession of armed trochanters, in its pubescence being not short and in its coarser puncturation.

In Raffray's table of species, *Proc. Linn. Soc. N.S.W.*, xxv. (2), p. 227, it would be associated with those species falling under the heading "Entirely punctate." A female from Bacchus Marsh collected by Mr. Oke apparently is referable to this species, but differs in having its antennae unicolorous and in its prothorax not being tinged with black.

Type in Author's collection.

TYROMORPHUS TIBIALIS, n. sp.

♂ Dark reddish castaneous; head, abdomen and four apical joints of each antenna black or blackish, rest of antennae, palpi and legs light reddish-brown; the whole nitid; very sparsely clothed with short, pale, semidecumbent pubescence.

Head lightly broader than long, truncate in front, before eyes, lightly narrowed, behind, widely rounded to base; with two small interocular foveae, and a few scattered punctures. Palpi with second joint subtriangularly produced within, apical segment furnished with a moderately strong seta at summit. Antennae rather long, joint 1 as long as 2 and 3 combined, 2 subcylindric, 3-6 subequal and a little shorter than 2, 7 slightly wider than 6, 8 obconic, shorter than 7, 9 obconic, about one and one half times wider and longer than 8, 10 transverse lightly wider and shorter than 9, 11 subovate, equal in length to the sum of the three preceding joints. Prothorax about as wide as long, sides evenly rounded to their widest part situated about apical third, thence lightly arcuate to base; with a basal fovea, and puncturation much as on head. Elytra transverse, shoulders raised, sutural striae entire, dorsal traceable to about apical fourth, both sutural and dorsal striae widely and deeply impressed at their bases; with puncturation as on prothorax. Abdomen longer than elytra, very convex and depressed towards apex, first segment with a very short carina on either side. Undersurface of abdomen lightly impressed on disc. Metasternum widely and deeply impressed. Front trochanters in middle and front femora at base, armed with a short acute spine, each spine surmounted with a little bundle of setae; middle trochanters armed with a flattened protuberance, this rounded at apex. Femora moderately robust. Tibiae strongly sinuate on apical halves, the intermediate thickened to about middle, where they are furnished with a short tooth, their apical extremities also bluntly produced internally.

Length, 2 mm.

Habitat.—Victoria; Warburton, in flood debris (F. E. Wilson).

Raffray divided the Australian species of the genus *Tyromorphus* into two sections—(1) Entirely punctate, (2) Entirely smooth. This species belongs to the second section, and it appears to be somewhat closely related to *laevis* Raff. (5, p. 232), the male of which Mr. A. M. Lea tells us in *Proc. Linn. Soc. N.S.W.*, 1911, p. 452, has the intermediate tibiae dentate in the middle. It may,

however, be differentiated from that species by reason of its armed intermediate trochanters, carinated first dorsal segment of abdomen, and by its smaller size.

Type in Author's collection.

HAMOTOPSIS METASTERNALEIS Lea.

(Proc. Linn. Soc. N.S.W., xxxvi. (3), p. 454.)

Mr. Lea in his notes at the end of the description of this species states that on the type there is, on the apparent first dorsal segment of abdomen, a very narrow longitudinal carina, but as it is slightly oblique and not exactly median it may possibly not be typical. Before me are three specimens of this species collected by myself at Mount Lofty, South Australia, from nests of the ant *Amblyopone australis* Er. I find that in all of them the carina mentioned by Mr. Lea is present, but is median, and is continued to the apex of the apparent second segment. A specimen in the collection of Mr. A. H. Elston, also from the same locality and same host, has the carina placed centrally, but in this case it traverses little more than half of the apparent first segment. It therefore appears that this carination is a somewhat variable character in this species.

TMESIPHORUS FORMICICOLA, n. sp.

♂ Reddish castaneous, elytra and palpi paler; moderately clothed with a pale, very short, decumbent pubescence, and with a prominent fascicle of golden hairs on either side of head at base.

Head about as broad as long, front impressed longitudinally between antennal ridges, with two not very prominent interocular foveae, and with a conical fascicle-clad tubercle behind each eye; with dense rounded punctures becoming somewhat rugose towards front; antennae long, reaching about middle of elytra; joint 1 cylindric, longer than 2 and 3 combined, 2 slightly broader than 3, 2-7 subequal in length, 8 shorter, 9 longer than 8, 10 shortest of all, 3-10 of equal width, 11 which alone forms the club longer than the five preceding, pyriform; palpi with the spine on second segment lightly, and on the third strongly, curved. Prothorax about equal in length and breadth, widest slightly in advance of middle, thence strongly arcuate to base which is wider than apex; with a small medio-basal fovea, and a large fovea on each side low down; puncturation as on head. Elytra strongly transverse, smooth, dorsal striae well defined, reaching about middle of elytra, each widely sulcate at base. Abdomen elongate, at broadest wider than elytra; with a well defined longitudinal carina on either side traversing the first and half of the second segments. Undersurface with metasternum deeply and widely sulcate on its apical half and second and third segments of abdo-

men lightly impressed.

Length, 2.75 mm.

♀ Unknown.

Habitat.—Western Australia; Mundaring (J. Clark). In nest of small black ant.

Differs from all other described Australian species of *Tmesiphorus* by its remarkable antennal club, consisting of one segment only.

Type in Author's collection.

ENDOMYCHIDAE.

DAULOTYPUS GIBBOSIPENNIS, n. sp.

Reddish flavous, tarsi paler, basal half of prothorax, scutellum palpi, legs, more or less, and antennae except two basal segments and apical two thirds of ultimate segment, black or deeply infuscated; moderately clothed with fairly long, erect setae, these interspersed with a shorter pubescence on sides of both head and prothorax.

Head lightly impressed between antennae, with only faint indications of puncturation. Clypeus without impressions. Antennae moderately stout, first joint a little more robust than second, third twice as long as fourth, and about one and one-half times longer than the second, 4, 6, 8 subequal, 5 and 7 longer, subequal, 9 about as long as 7 but wider, dilated from base to apex, 10 longer and wider than 9, 11 lightly longer than 10, bluntly pointed. Prothorax nearly twice as wide as long, widest near apex, sides finely margined; bluntly toothed at widest part and again at about apical third; hind angles acute; with a narrow transverse, sharply defined furrow close to base, this meeting on either side near lateral borders a longitudinal furrow, these latter a little wider and deeper than the transverse furrow and not quite attaining middle of prothorax; anterior half of prothorax strongly convex, posterior half strongly depressed; puncturation wanting. Elytra much wider than prothorax, widest a little in advance of middle, with four prominent elevations at base, two humeral and two nearer suture, with somewhat irregular rows of fairly large punctures, becoming less conspicuous posteriorly. Abdomen with first ventral segment about equal in length to the sum of the following three. Legs with femora thin, the posterior ones passing fourth segment of abdomen. Posterior tibiae curved.

Length, 2.75 to 3 mm.

Habitat.—Queensland; Goodna, in a rotten log (F. E. Wilson).

Two species have previously been assigned to this genus, viz., *picticornis* Lea (12), and *minor* Lea (13). From *picticornis* my species may be readily differentiated by its much smaller size, its non infusate head, the different shape of the sides of its prothorax, by its hind femora passing the fourth abdominal segment, and in its possession of elytral elevations. From *minor* it may be

separated by its head being not infuscated, its prothorax not more than twice as wide as long, its clypeus without impressions, and also by its possession of elytral elevations.

The shape of the two apical segments of the antenna vary according to the position of observation. From some directions the subapical segment is seen to be obtusely produced, and passes somewhat the base of the apical segment.

Type in Author's collection.

OEDEMERIDAE.

TECHMESSA EPHIPIATUM, n. sp.

Reddish testaceous, nitid; head less muzzle and antennal joints 5-11, deeply infuscated; a black area occupying a little less than half the length of elytra, beginning at about one-sixth, this area gradually narrows towards, but does not quite attain the lateral margins.

Head strongly transverse, greatly decreasing in width towards base and apex; eyes placed laterally, protruding; with sharply defined round punctures, fairly evenly distributed, but becoming smaller in front. Antennae reaching about middle of elytra, joint 2 short, 3 about one and one half times longer than 2, 4-10 subequal, a little longer than 3, 11 longer than 10, pointed. Prothorax lightly narrower than head, evenly rounded to beyond middle, thence arcuate to base; with a large shallow depression on either side of disc a little behind middle; puncturation as on head, but if anything a little more sparse on median line, which is only very faintly indicated at apex. Scutellum more densely punctured than prothorax. Elytra nearly twice as wide as prothorax, shoulders evenly rounded, sides parallel to about two-fifths, thence gradually increasing in width to about three-fifths, from whence they are gently rounded to apex; shallowly depressed along suture near base; with punctures about the same size as those on prothorax. Prosternum less, mesosternum more, densely punctured. Metasternum with a discal area behind middle, and most of its posterior declivity impunctate. Abdominal puncturation less sharply defined.

Length, 4 mm.

Habitat.—Queensland; Blackall Ranges (F. E. Wilson).

This species differs from the description of *bifoveicollis* Lea (14), in its general coloration, unicolorous clothing, in the median line of prothorax being almost totally wanting, and in its elytra not being parallel sided.

Type in Author's collection.

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ART. VI.—*The Technique of the Nanson Preferential
Majority System of Election.*

By J. M. BALDWIN, M.A., D.Sc., F.Inst.P.

[Read 15th July, 1926.]

I.

In 1925 a joint conference of the University Council, the Standing Committee of Convocation, and the University Association was appointed to consider the question of methods of voting at University elections. The Conference, having decided at its first meeting in favour of a system requiring election by a majority, considered that, of the different majority methods available, that devised by Professor Nanson (*Trans. Roy. Soc. Vic.*, xix., p. 197, 1882) was the best, but that the labour involved in the counting, except when the number of candidates was small, might be excessive.

Mr. Picken (Council) in a memorandum drew the attention of the conference to an alternative method of tabulating the votes given by Mr. G. Hogben (*Trans. N.Z. Inst.*, xlv., p. 304, 1913), and at the second meeting Mr. Le Couteur (Association) and Dr. Baldwin (Standing Committee) both expressed the opinion that the Nanson method with the Hogben tabulation could be carried out without undue labour, provided that the number of candidates was not very large. A sub-committee was appointed to conduct a test election, and the result showed that this opinion was justified.

At the third meeting it was suggested that, as a first step in an election with a large number of candidates, the number should be reduced on a count of first preferences by the rejection of those at the bottom of the list or the election of those at the top or by both methods, and Dr. Baldwin was asked to draw up a memorandum embodying these suggestions.

This was considered at the fourth meeting, when it was resolved to recommend that the Nanson method of voting, with a generalized form of the Hogben tabulation, should be adopted for the next election, and Mr. Phillips (Standing Committee) and Dr. Baldwin were appointed to draw up the necessary Statute. This draft statute, with some verbal alterations suggested by Sir Leo Cussen, was finally adopted by the Council and the Standing Committee.

In the course of these meetings and elsewhere, a technique was evolved, which was tested at the University elections last Decem-

ber. The experience gained there has shown that the method is a thoroughly practical one, and does not involve an undue amount of labour provided the number of candidates does not exceed 10.

II.

No critical examination of the different methods of voting is here attempted—that has already been fully done in Nanson's paper cited above. The present paper is a detailed description of a method of carrying out Nanson's system in its most general form, allowing the voter to indicate preferences for as few or as many candidates as he pleases, and to bracket two or more candidates if he so desires. It is thus an extension of Hogben's paper, where the tabulation is for a single member electorate only and incomplete papers and bracketing are not considered. Actually such papers are dealt with almost as easily as other papers, so that any expression of preference by a voter will be recorded and have due weight in the final result.

In one detail only is the Nanson system departed from. In that system all candidates who are not above the average are rejected *en bloc*; here, as in the Trinity College Dialectic Society's elections (Nanson, *loc. cit.*, p. 217), the lowest only is excluded. In the original system this short cut meant a considerable saving of time, in the present method the extra time involved in carrying out the more rigorous procedure is quite negligible—a matter of a very few minutes only.

III.

RULES.

(*Melbourne University Calendar*, 1926, Statute 34, Division 1, Sections 21 to 26.)

1. The Voter shall indicate the order of his preference by writing numbers on his ballot paper opposite the names of all or some or one of the candidates. A number opposite the name of a candidate shall indicate a preference for that candidate over all candidates opposite whose names a higher number or no number is written, and the same number or no number opposite the names of two or more candidates shall indicate that the voter considers these candidates of equal merit.
2. The number of preferences for each candidate over each other candidate shall be ascertained. In each case where on a voting paper no preference is expressed as between two candidates, half a preference is to be credited to each of the two candidates. Where no preference is expressed as between more than two candidates, the candidates so bracketed shall be dealt with two at a time. The number of preferences shall be arranged in tabular form in which one column (ver-

- tical) and one row (horizontal) are assigned to each candidate, the number of preferences (for instance) for candidate P over candidate Q being written down in column P, row Q.
3. The numbers in each column shall be summed. The column with the lowest sum and the corresponding row shall be excluded, and the remaining numbers in each column shall again be summed. The column with the lowest sum at this stage and the corresponding row shall be excluded, and this process of summing and exclusion shall be repeated until only two columns are left. Of the candidates to whom these columns refer that one who has the majority of preferences over the other shall be declared elected.
 4. If a further vacancy is to be filled, the column and row assigned to each elected candidate shall be excluded, and the process of election carried out in precisely the same manner as before.
 5. If at any stage two columns (for instance, those assigned to B and C) have the same sum, and there is no other column with a lower sum,¹ then the column C shall be excluded if B has a majority of the preferences as between B and C, but if B has exactly half of the preferences as between B and C, the Returning Officer shall decide which column is to be excluded. If, at any stage, three or more columns have the same sum, and there is no other column with a lower sum, the Returning Officer shall decide which column is to be excluded.
 6. At any stage of the scrutiny the Returning Officer may adopt any modification which is the mathematical equivalent of the portion of the process for which it is substituted.

IV.

These rules may be used as they stand, but the labour of tabulation may be considerably shortened by a suitable arrangement of the work and by variations of the procedure which, however, can be shown by strict mathematical reasoning to lead to the same result, and are therefore allowable under Rule 6. Details of the procedure are given in the following instructions.

INSTRUCTIONS.

(The process described in a sentence or paragraph following an * is a mathematical equivalent of one laid down in the preceding rules.)

1.—An alteration has been made here, to provide more explicitly for the case where the equality occurs when all columns but those with equal sums have been excluded.

1. Sort the voting papers according to first preferences, and count the number of first preferences allotted to each candidate.

*For each paper where any number, p , of candidates are placed equal with a preference ranking as first, $1/p$ is to be credited to each of the candidates so placed.

*If the number of first preferences received by any candidate exceeds half the number of voting papers, that candidate is placed first at once, and is excluded from all further counts and tabulation.

2. If any candidate is elected under (1) redistribute the voting papers on which he is given first or equal first preference according to the preferences ranking as first preferences among the remaining candidates, and determine the total number of preferences ranking as first credited to each.

*For each paper where any number q of candidates are placed equal with a preference which ranks as first at this stage, $1/q$ is to be credited to each of the candidates so placed.

*If after the redistribution the number of preferences ranking as first preferences received by any candidate exceeds half the number of voting papers, that candidate is placed second, and is excluded from all further counts and tabulation. This process may be continued as far as possible.

3. (*For occasional use only.*) Sort the voting papers according to last preferences (candidates against whose names no number is written rank last), and count the number of last preferences allotted to each candidate.

*For each paper where p candidates are placed equal last, $1/p$ is to be debited against each of the candidates so placed.

*If the number of last preferences received by any candidate exceeds half the number of voting papers, that candidate is placed last, and is excluded from all further counts and tabulation.

4. To the candidates who remain after the completion of the above processes allot rows and columns² according to the count of first preferences, starting with the highest in the *top left-hand* corner, referred to the recording scrutineer.
5. The scrutineers work in pairs. Any pair, A and B say, deals first with a group of papers on each of which the first preference has been given to the same candidate, S say, and to no other. A has the voting papers

2.—The size of the tabulation sheet should not exceed 24 inches by 20 inches. If each column is 2 inches wide, and each row $1\frac{1}{2}$ inches wide, 200 preferences can readily be recorded in each space, and so 400 voting papers can be tabulated on the sheet.

and a number of strips. He fastens a strip over the row assigned to S, *and B writes the number of voting papers in the group in each of the spaces of the column assigned to S, above the diagonal through the top left-hand corner. Taking the first voting paper, A now calls out the name of the candidate with the second preference, and places a strip³ on the corresponding row, *while B puts a stroke in each of the uncovered spaces above the diagonal in the corresponding column. The third, fourth, etc., preferences are dealt with in a similar way.

Where no preference is indicated as between two or more candidates, A calls out (in the order in which they appear in the tabulation) the names of such candidates. Taking the row of the first such candidate, B puts a dot in the columns corresponding to the second, third, etc., such candidates; then taking the row of the second such candidate, he puts a dot in the columns corresponding to the third, etc., such candidates; and so on. This having been done, strips are placed over the rows in turn, and strokes put in the uncovered spaces as before.

When all the rows have been covered, the strips are gathered by A, and a similar process is gone through with each of the voting papers in turn, until the group is finished. Another group is then dealt with in a similar manner, and so on until all the papers have been tabulated.

Where the remaining candidates are numbered on a voting paper in the order in which their names appear on the tabulation, it will be found that no further strokes will need to be put on the tabulation for that paper.

6. As the treatment of voting papers with bracketing and those that are incomplete is slightly different from that of other papers, it is well to have all such voting papers tabulated by a special pair of scrutineers. If A and B, dealing with papers on which S has first preference, transfer any voting papers to the special pair, B must be careful to see that these papers have not contributed to any of the entries in his tabulation. If the preferences on a voting paper have been partially recorded before the bracketing is noticed, it is inadvisable to transfer the voting paper to the special scrutineers.
7. At the close of the tabulation, the number of strokes in each space is counted. To this is added half the number of dots in the same space. The results from each

3.—This use of strips was suggested by Mr. Le Couteur. The strips should be of cardboard, stiff enough to be placed in position with one hand, somewhat narrower than the rows, and long enough to reach across the sheet.

pair of scrutineers are added together, and thus the total number of preferences of each candidate over each candidate before him on the tabulation is obtained. *These are written on a similar table, and the spaces below the diagonal are filled in by subtracting the number in the complementary space above the diagonal from the total number N of voting papers. This completes the tabulation.

Note.—If the counting be carried on at several centres, the third part of (1) and the whole of (2) and (3) are inapplicable. The order of columns and rows will probably be different for the different centres, but when the tabulations are all received at the head centre it will be a simple matter to combine them into a single tabulation for the whole electorate.

8. Inspect the table and ascertain—

- *(a) if in any column each number is greater than $N/2$. In such case the candidate to whom that column refers is placed first, and his row and column are covered with fastened strips.
- *(b) if now in any column each uncovered number is greater than $N/2$. In such case the candidate to whom that column refers is placed second, and his row and column are covered with fastened strips.
- *(c) if in any column each number is less than $N/2$. In such case the candidate to whom that column refers is placed last, and his row and column are covered with fastened strips.
- *(d) if now in any column each uncovered number is less than $N/2$. In such case the candidate to whom that column refers is placed second last, and his row and column are covered with fastened strips.

*These processes may be continued as often as possible.

9. When as many candidates as possible have been placed by (8), the uncovered numbers in each column are summed. The column with the lowest sum and the corresponding row are covered with unfastened strips (see section 11 below), and the uncovered numbers in each column again summed. The column with the lowest sum at this stage and the corresponding row are then covered with unfastened strips, and this process of summing and covering is repeated until only two columns are left uncovered. Of the candidates to whom these columns refer that one who has the majority of preferences over the other shall be placed next in order of those elected. Removing all the unfastened strips, his row and column are now covered by fastened strips.
10. *Again inspect to see if any further candidates can be placed by inspection as in (8). If so, cover the corresponding rows and columns by fastened strips.

11. Proceed again by summing and covering to place another candidate, and so on until a sufficient number have been placed to enable the successful candidates to be determined.

It is to be noted that as each candidate is definitely placed, his row and column are covered with *fastened strips*, but, when a row and column are to be temporarily excluded in the process of placing another candidate, they are covered with *unfastened strips*.

12. If at any stage it is necessary to discriminate between two columns (for instance, those referring to R and S) which have the same sum, then the column S shall be excluded if R has a majority of the preferences as between R and S, but if R has exactly half the preferences as between R and S, the Returning Officer shall decide which column is to be excluded. If it is necessary to discriminate between three or more columns which have the same sum, the Returning Officer shall decide which column is to be excluded.
13. The most complete check will be given by making an independent tabulation in precisely the same way as the first was done. The two are compared, and where any difference is found the voting papers are gone through, the preferences as between each pair of candidates for whom there is a difference being counted. If the result agrees with the result in one of the tables, it may be assumed that this result is correct. If, however, it agrees with neither, a second count for this pair of candidates may be made, and so on until reasonable certainty has been secured.

As a general rule, however, it will probably not be necessary to carry out the complete retabulation, but a count of the preferences as between two candidates should be carried out wherever it appears possible that a slight error in the tabulation could affect the election. The most usual case will be where, when the candidates are reduced to two, each of them has approximately half the preferences over the other.

V.

Actually at the recent University elections there were 1550 voting papers and 6 candidates for the Council, and 688 voting papers and 9 candidates for the Standing Committee. Dealing with the papers occupied some 12 scrutineers about 13 hours, one-third of which was spent in opening the envelopes and checking the names of the voters.

None of those present except the Returning Officer (Mr. Bainbridge) and myself had had any previous experience of the tabulation. No difficulty whatever was found with the ordinary

papers, but a little preliminary practice was shown to be advisable with voting papers which had bracketing or were incomplete, so that the treatment of them may become mechanical.

The above figures enable an estimate of the time necessary for obtaining the result of any election by this system to be made. In round numbers a pair of scrutineers without previous experience can deal with 1000 preferences per hour. The number of preferences on a voting paper is $n(n-1)/2$, where n is the number of candidates. If then N is the number of voting papers, and m the number of scrutineers, the time taken would be approximately $N.n(n-1)/1000m$ hours.

VI.

PROCEDURE WHERE NUMBER OF CANDIDATES IS LARGE.

It will be seen that the amount of work involved increases rapidly with the number of candidates, and when the number of candidates exceeds 10 may well become too great. When there are more than 10 candidates, the procedure described below will enable the result to be obtained with almost mathematical certainty, while at the same time reducing to 10 the number of candidates whose preferences are to be tabulated.

Since the object of the election is simply to elect a certain number of candidates, and not necessarily to place them in order, it will be found that for a candidate to be elected by the proposed short cut who would be rejected by Nanson's system, or vice versa, requires that the position of such a candidate must differ by *at least* six places from the position he would occupy if the Nanson system were adopted in its entirety. The likelihood of this happening is so infinitesimal that it may be disregarded. The procedure recommended is as follows:—

1. Whenever the number of candidates exceeds 10, and the number of vacancies exceeds 5, make use of the method⁴ described in (2) below to elect a certain number of candidates. If the excess of the number of candidates over the number of vacancies—
 - (a) is 5 or more, the number to be so elected is equal to the number of vacancies in excess of 5;
 - (b) is less than 5, the number to be so elected is equal to the number of candidates in excess of 10.
2. Determine the number of first preferences allotted to each candidate. For each paper where any number p of candidates are placed equal with a preference ranking as first, $1/p$ is to be credited to each of the candidates so placed.

4.—Ware's method, modified to allow of bracketing of candidates.

3. Exclude provisionally the candidate with the lowest number of first preferences so determined, and determine by the above rule the number of preferences ranking as first preferences allotted to each remaining candidate. Continue this process of provisional exclusion of the candidate with the lowest number of preferences ranking as first preferences and the determination of the number of preferences ranking as first preferences allotted to each remaining candidate until one only remains. This candidate is declared elected, and is excluded from further scrutiny.
4. Including those provisionally excluded, determine the number of preferences ranking as first preferences allotted to each remaining candidate, and proceed as in (3), excluding provisionally the candidates one by one until one only is left, who shall be declared elected, and excluded from further scrutiny.
5. Repeat the process in (4) as often as is necessary to elect the number of candidates given by (1).
6. At any stage a candidate who has an absolute majority of preferences ranking as first preferences shall be declared elected forthwith, and excluded from further scrutiny.
7. If, after the election of such candidates (if any) as shall be elected under (1), the number of remaining candidates is greater than 10, the number shall be reduced to 10 by the rejection of candidates as follows:—

Determine by the rule in (2) the number of preferences ranking at this stage as first preferences allotted to each of the remaining candidates. Exclude provisionally the candidate with the highest number of preferences ranking as first preferences, and again determine the number of preferences, ranking as first preferences, allotted to each of the remaining candidates. Continue this process of provisional exclusion of the candidate with the highest number of preferences ranking as first preferences, and the determination of the number of preferences ranking as first preferences allotted to each remaining candidate until one only remains. This candidate is declared rejected, and is excluded from further scrutiny.
8. Including those provisionally excluded, determine the number of preferences ranking as first preferences allotted to each remaining candidate and proceed as in (7), excluding provisionally the candidates one by one until one only is left, who shall be declared rejected, and excluded from further scrutiny.
9. Repeat the process in (8) until the number of remaining candidates has been reduced to 10.

10. If at any stage under (3) to (9) it be necessary to discriminate between candidates with an equal number of preferences that rank as first preferences at that stage, the Returning Officer shall have a casting vote.

Note.—In the above, 10 and 5 may be replaced by $2n$ and n respectively, where $2n$ is the number of candidates that can be dealt with conveniently under the Nanson system.

VII.

As the technique of Ware's method is well established, it is unnecessary to give here any instructions for its use, and the method of dealing with bracketed votes is clear from Instructions (1) and (2) earlier in this paper. At each stage each group of papers should be labelled to show to which candidate or candidates first preference was given, and which candidates have preferences ranking at that stage as first. This will render the counting of bracketed preferences an easy matter, and also will facilitate redistribution.

When the number of candidates has been reduced to 10 as described above, further dealing with the voting papers will be facilitated by placing over the voting paper a card which has been cut so that only those portions of the paper referring to the 10 remaining candidates can be seen.

VIII.

In conclusion, it cannot be too strongly emphasised that the Nanson system is *not* a system of allotting *marks*. In it the voting paper is simply and solely a means of showing which one of each pair of candidates the voter prefers, and the method of tabulation adopted shows at a glance how many voters preferred P to Q. The candidates are eliminated one at a time, until two only, P and Q say, remain.

If a voter expressed no preference as between P and Q, either by bracketing them, or by not placing a number against their names, this has been indicated by a dot in column P, row Q, and a dot in column Q, row P. Each dot has been counted as half a preference, but as there is the same number of dots in each of the two spaces which show P's preferences over Q, and Q's preferences over P, the dots exactly balance, and it is immaterial what value is assigned to a dot as far as the contest between P and Q (or any other pair of candidates) is concerned.

When no candidate has a majority over each of the other candidates, it is necessary to adopt some criterion for the exclusion of a candidate. The criterion adopted in the above method is that the candidate with the lowest number of preferences shall be provisionally excluded. In order that each voting paper should have equal weight in this exclusion, it is necessary, where no preference has been expressed as between two candidates, to

credit each of the two candidates with half a preference. Incidentally, the use of the dot reduces the work of tabulation to less than one-half, as with it the detailed tabulation need only be made on one side of the diagonal.

In Ware's method, the criterion is that the candidate with the lowest number of first preferences shall be provisionally excluded, and the rule adopted above for counting bracketed preferences is that necessary for giving equal power to each voter. Owing to this difference in the criterion adopted, Ware's method may lead to the anomalous result that a candidate may obtain a majority of preferences as against each other candidate, and yet not be elected. (Nanson, *loc. cit.*) Thus Ware's method does not fulfil the fundamental condition which a true majority system must fulfil. Under Nanson's method such a candidate would *always* be elected, so that Nanson's method is theoretically sound, and, if the scrutiny is carried out as described in this paper, is also a method which can be readily applied in practice.

END OF VOLUME XXXIX., PART I.

[PUBLISHED 11TH NOVEMBER, 1926]

ART. VII.—*The Total Solar Eclipse of May 9th, 1929.*

By Z. A. MERFIELD, F.R.A.S.

[Read 21st October, 1926.]

On May 9th, 1929, a Total Solar Eclipse will take place, and will be visible from Northern Sumatra, Malaya and Cochin China. It seems worth directing attention to the fact that this is the only Total Solar Eclipse in the next ten years to exceed 160 seconds duration, and therefore of any real use in the solution of Solar Physical problems.

No information regarding trigonometrical surveys of the country has been received up to the present, so it is therefore hardly possible to ascertain what places of importance lie on the centre line. Special meteorological observations are in hand, and the result of these will be made available in due course.

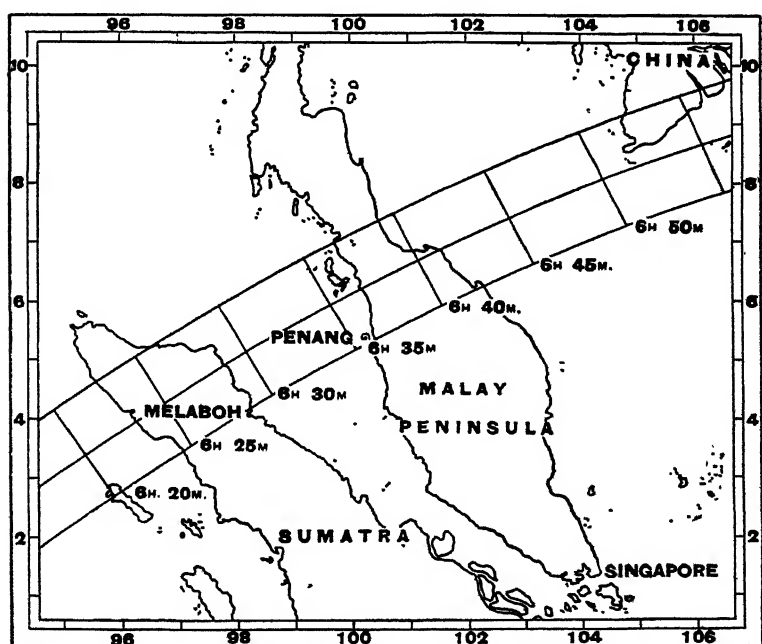


FIG. 1.

Track of Total Solar Eclipse of 9th May, 1929.

ART. VIII.—*A Note on Solar Radiation in the Lyman Region and Far Ultra Violet.*

By Z. A. MERFIELD, F.R.A.S.

(With Plate VII.)

[Read 21st October, 1926.]

The D_1 and D_2 lines, according to Mitchell (1) reach a height of 1000 kms. in the Chromosphere, and Saha subsequently showed that the ionization potential of sodium (5.11 volts) is so low that above this level no appreciable quantity of sodium would remain un-ionized. The characteristic absorption lines of the ionized atom lie in the far ultra violet and the height which such atoms attain cannot therefore be directly ascertained. In following up this subject, Milne (2) suggested that since solar radiation in the far ultra violet is probably too weak to exert any appreciable pressure, the sodium atoms which chance to become ionized will not be supported, and he concluded that 1000 kms., the limit of the neutral atoms, would also be the limit of the ionized atoms. The Earth's atmosphere begins to absorb strongly beyond λ 3000, and we have as yet little or no knowledge of continuous absorption in the solar envelope. According to Fabry and Buisson (3), and also H. H. Plaskett (4), the continuous spectrum of the Sun conforms closely with that of a black body. How far we are at liberty to extend these results into the ultra violet is difficult to say. The intensity of solar radiation in the extreme ultra violet is therefore largely a matter of conjecture.

Observations made by the author¹ at the Eclipse in Sumatra, 1926, show that D_1 and D_2 reached 3300 kms. and it is suggested that stripped sodium atoms cannot exceed this level because the L radiations of sodium, the longest of which is 376.5 Å.U. (5), lie in the Lyman region, where the intensity of solar radiation is insufficient to support such atoms. It remains to show some jus-

1.—A full account of this work will be published in due course. The observations were made with a moving plate objective grating spectrograph. On the spectrogram reproduced the scale of heights is such that 1 mm. on the spectrogram is equivalent to 275 kms. in the chromosphere. Direct measures give Na 3300 kms., Ca 1500 kms., Ca 10,000 kms., Ba 1400 kms. These results are in good agreement with observations (unpublished), made in Australia at the Total Solar Eclipse, 1922. Corrections have still to be made for atmospheric and instrumental absorptions or losses, also spectral sensitivity of the plate emulsion. The combined effect of these, however, does not vary much over the range of the spectrum under consideration, so the relative heights as measured directly from the spectrogram will not be seriously in error. On the original spectrogram the precaution has been taken to impress a standard solar spectrum and standard squares, so that the above corrections may be ascertained.

tification for this suggestion, and also the assumption made by Milne regarding the intensity of solar radiation in the far ultra-violet.

When the valency electron of the sodium atom is removed we are left with a "stripped atom," and there are then two possible alternatives:—

- (a) The next absorption may be one of the L radiations, or
- (b) One of the L electrons may be only lifted into one of the M levels, leaving the atom in the normal state for the absorption of the principal series of enhanced lines². In such a state the atom is not likely to capture an electron—in fact, it is more easily ionized than before.

If any sodium atoms exist above 3300 kms., there is little doubt that they must be in an almost completely ionized state. Ionized calcium exists to 10,000 kms., and we will therefore have a mixture of stripped sodium, ionized calcium and free electrons. The ionization potential of calcium, 6.08 volts, is considerably higher than that of sodium, 5.11 volts, so there will be a tendency for the ionized calcium atoms to capture electrons and become neutral. In that case, we would expect to find some trace of λ 4227 neutral calcium above 3300 kms. In reality my observations show that λ 4227 only reaches 1500 kms. The inference to be drawn is that the existence of stripped, and hence ionized, sodium atoms above 1500 kms. is extremely unlikely, and as a corollary that solar radiation, in the extreme ultra violet and Lyman region, is very weak.

Before dismissing this subject, it might be mentioned that the ionization potential of barium, 5.12 volts (6), is almost identical with that of sodium, but in this case the principal lines of the ionized atom lie in the easily accessible region of the solar spectrum. A comparison of the heights of the ionized lines λ 4934 and λ 4554 of barium, and λ 4227 neutral calcium will, therefore, afford an admirable test (other things being equal) of the foregoing theory.

λ 4934 and λ 4554 not only lie in the observable region, but near F and between F and G respectively, in which region we know solar radiation can exert a very strong pressure. We might therefore expect λ 4934 and λ 4554 to reach heights commensurate with the H and K lines, which lines reach 10,000 kms. In reality λ 4934 only reaches 1400 kms., which is in keeping with the theory advanced. λ 4554, unfortunately, cannot be used to test the theory as this line appears as a blend with a line of zirconium.

2.—A sodium atom which has lost its valency electron is referred to as a stripped atom. In such a state the atom is capable of absorbing and subsequently emitting a series of radiations in the Lyman region, the longest of which is 376.5 A.U. The term "ionized sodium atom" is used to denote a sodium atom with its valency electron removed to infinity as before, but with one of its L electrons raised to one of the M levels. In this state the atom is capable of absorbing, and subsequently emitting the well-known, many-lined, enhanced spectrum.

Bearing on Terrestrial Phenomena.

The electrical state of the Earth's upper atmosphere is of considerable importance in connection with the transmission of wireless waves, and was the subject of a recent discussion of the Royal Society (7). The evidence obtained from Radio work indicates that the upper air is considerably ionized or may contain a moderate number of free electrons. Appleton and Barnett (8) have assigned 10^5 as the lower limit to the number of free electrons per cubic cm. at 80 kms. above the Earth's surface, but there is ample evidence to show that the concentration is considerably greater. The electrical state of the upper air has been ascribed to various causes, but mainly to direct ionization by ultra violet light in the Sun's rays, and also to the formation of ozone by wave lengths shorter than 1800 Å.U. (7) and its subsequent decomposition into ions. The pertinent question is whether sunlight contains the ultra violet radiations necessary for either (or both) of these processes.

In discussing this subject it seems desirable to distinguish between two kinds of radiation, bright line emission and continuous emission. The latter we have already seen to be weak in the far ultra violet and Lyman region, and need not be considered any further at present.

According to Russell (6), the percentage of calcium remaining un-ionized in the Sun's reversing layer at a height where the pressure falls to 10^{-6} Ats. is 0.007 and of ionized calcium 83.6. These figures if correct show that even at moderate elevations an appreciable quantity of calcium (approximately 16.4%) is doubly ionized, and it has been suggested to me by Professor Grant that if the high level calcium atoms eventually become doubly ionized there would be a copious emission of just those short wave lengths requisite for ionization of the Earth's upper atmosphere.

We have already seen that the reason why the ionized and stripped sodium atoms are not supported is because of the Sun's poverty in continuous radiation in the far ultra violet and the Lyman region. These are also the radiations necessary to support the doubly ionized calcium atoms, so we are faced with the conclusion that if the calcium atoms become doubly ionized they will not be supported, and will fall inwards towards the Sun until they capture an electron with which to absorb. The intensity of the short wave length radiations from this source will depend on how quickly the doubly ionized atom can find an electron, and climb up into the high levels again. St. John (9) gives the velocity of ascent of ionized calcium as 2 kms. sec.⁻¹. If a mobile equilibrium is established, it is plain that the intensity of the doubly ionized radiations will not be very strong. On the other hand, in spite of the low pressure at great heights, Milne (10) has given good reasons for believing that there will scarcely be an appreciable amount of the second stage ionization.

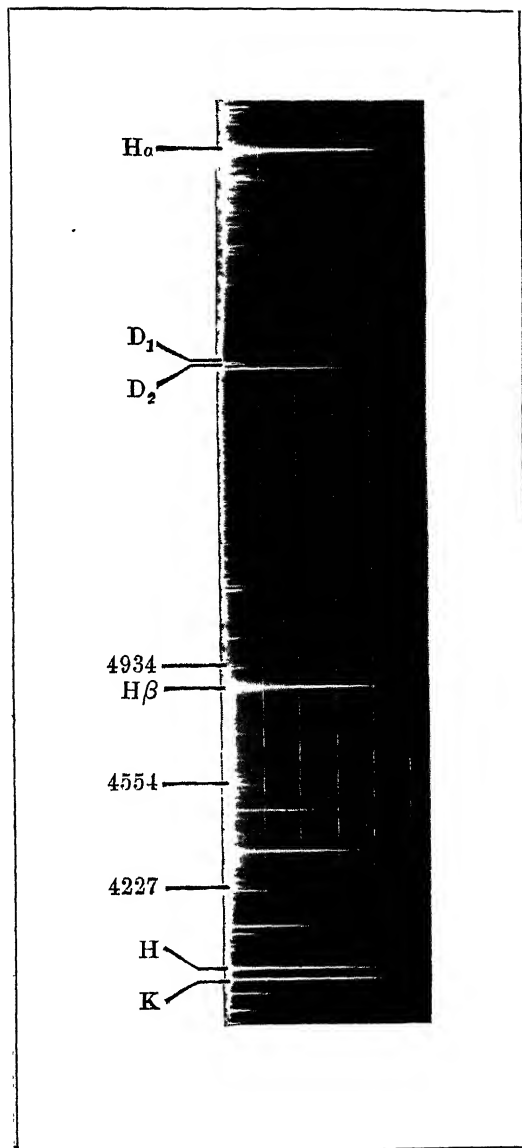
When all these matters are taken into account it seems that the theory of the formation of ozone at great elevations and the hypothesis of photo-electric ionization of the upper atmosphere by ultra violet radiations between say λ 3000 and the region of long X-rays are rather unsatisfactory. Nevertheless, the small intensity of these radiations in the Sun's rays may suffice and the ionization products may accumulate with time, but the hypotheses of very penetrating radiation (11) and swift-moving charged particles (12) seem on the whole preferable.

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EXPLANATION OF PLATE VII.

Flash Spectrum. Total Solar Eclipse, Sumatra, January 14th,
1926.



Flash Spectrum. Total Solar Eclipse, Sumatra, January 14th, 1926.

ART. IX.—*On the Bad Lands Deposits of Coburg, Victoria, and
their Mapping by Elutriation Methods.*

By R. B. PRETTY, M.Sc.

(With Plates VIII. IX.)

[Read 11th November, 1926.]

Contents.

- I. INTRODUCTION.
- II. PRELIMINARY SURVEY OF PREVIOUS HYPOTHESES.
- III. NATURE OF THE PRESENT INVESTIGATIONS.
- IV. RESULTS AND DISCUSSION OF THE MECHANICAL ANALYSES.
- V. RESULTS OF THE MICROSCOPICAL EXAMINATION.
- VI. SUMMARY OF THE EVIDENCE OBTAINED AT COBURG.
- VII. DISCUSSION OF THE HYPOTHESES IN THE LIGHT OF NEW EVIDENCE.
- VIII. CONCLUSION AND ACKNOWLEDGMENTS.
- IX. APPENDIX.—DESCRIPTION OF THE APPARATUS AND METHOD USED IN MAKING THE MECHANICAL ANALYSES.
- X. LIST OF REFERENCES.

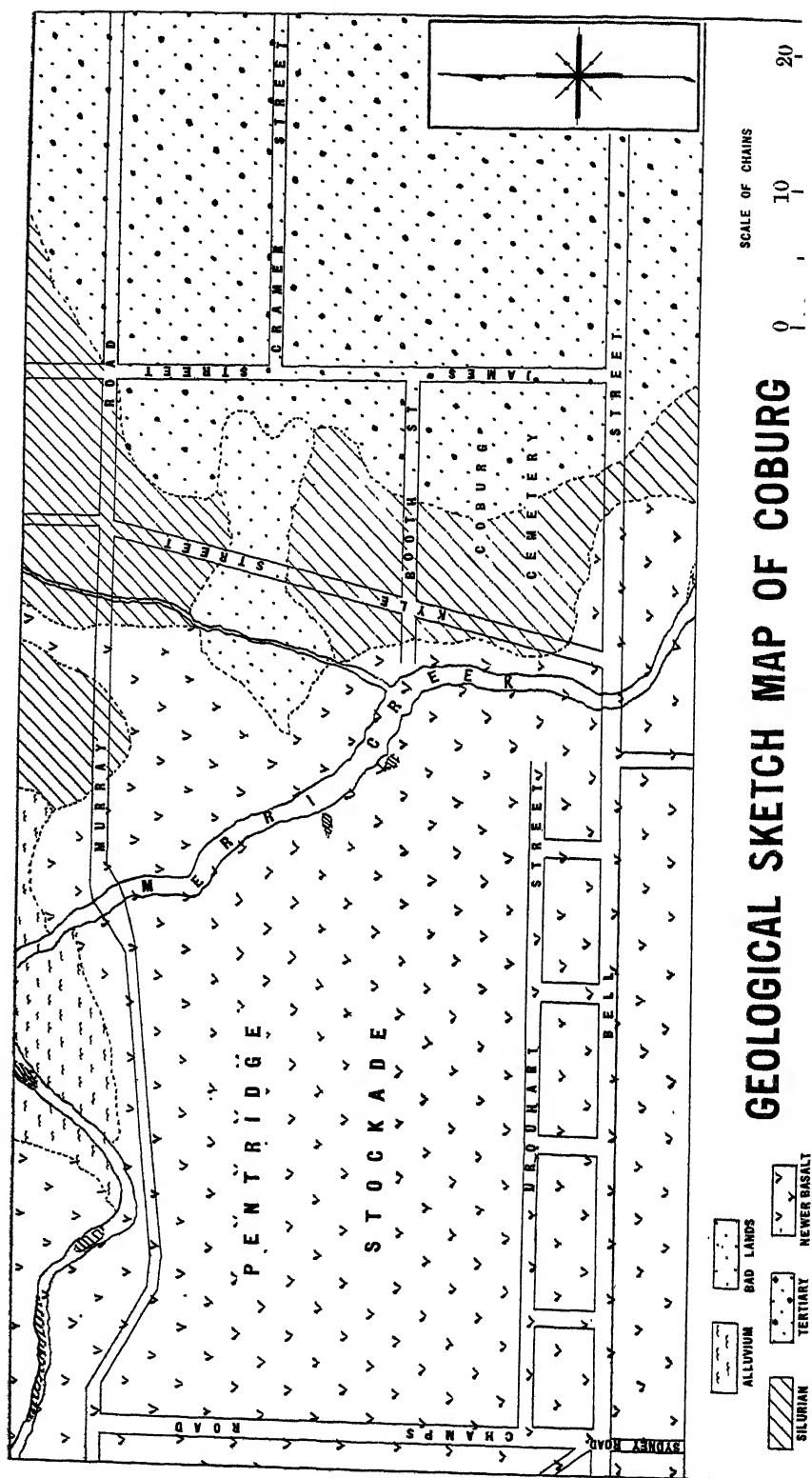
I. Introduction.

The work described in this paper was undertaken with a view to elucidating the relations existing between the normal marine Tertiary series and a deposit (hereafter referred to as the "Bad Lands" deposit) associated with it at Coburg.

The locality lies some six miles to the north of Melbourne, to the east of Pentridge Stockade, and occupies a limited area on the western slope of the rising land to the east of the Merri Creek. The Bad Lands area lies to the north of the Coburg Cemetery, to the west of James Street, and to the south of Murray Road.

In passing along Kyle Street, between Bell Street and Murray Road, the locality is easily distinguished by the canyon-like formation due to scouring out of the soft Bad Lands material by running water. This is its most characteristic feature, and has led to its being called the "Bad Lands."

making out some boundaries on account of the paucity of the In spite of the ease with which the two series may be separated actual rock exposures, the soil being often the only indication. In spite of the ease with which the two series may be separated when forming solid rock faces, as in cuttings, the actual surface indications on both the Silurian and Tertiary were surprisingly alike when examined together.



In addition, to the west of Kyle Street particularly, there is a thin mantle of hill wash material as a result of the scouring of the canyons in the Bad Lands nearer the top of the hill. Such hill wash can only be regarded as a thin film, and insufficiently thick to be represented as a distinct deposit in plan.

Physiographically the area consists of two parts. On the west is a comparatively level area which is almost wholly composed of basalt and which is mainly within the bounds of the Penal Establishment. To the east is an area consisting mainly of Silurian and Tertiary sediments. These two areas are separated roughly by the course of the Merri Creek, which drains both slopes and flows in a southerly direction to meet the Yarra.

The Silurian underlies all the rocks in this locality, and is the basement rock in the Melbourne district. The Silurian consists mainly of sandstone and shales, and specimens from the Coburg area have been already examined and described (7).

The next horizon to be found in this area is the aqueous Tertiary series. Two types of aqueous deposits may possibly be included here: the definite Tertiary such as occurs at Royal Park, Kew, Essendon and Keilor among other localities around Melbourne, and the Bad Lands deposit, which may perhaps be included here as an upper member, though the weight of evidence favours a post-Tertiary age for the Bad Lands.

It is with respect to the origin and relative age of the Bad Lands deposit and its relation to the definite Tertiary, and the use of the elutriation method to distinguish these two, that this paper is mainly concerned.

Several hypotheses² have been put forward assigning to the Bad Lands deposit different modes of origin, and different ages, but all hypotheses agree in calling the deposit not older than Tertiary.

The normal Tertiary is best seen at the top of the hill between Murray Road and Bell Street, and immediately south of the poultry farm which faces James Street. Here on the E. and N.E. of the Bad Lands area the Tertiary occurs as a coarse ferruginous gritstone, cemented into a fairly hard rock by dark brown limonite. This type appears to fringe the Bad Lands area on the E., N.E. and N., and then becomes masked by soil and vegetation as it passes over north-westwards to the Silurian.

The Bad Lands deposit consists of much finer-grained material than the Tertiary, and is quite unconsolidated, the limonitic cement of the Tertiary being typically absent. However, there is a characteristic hard capping forming the surface of the Bad

1.—The sources of all but two of these hypotheses are obscure, and they have not been published. The Leaching Hypothesis was a tentative one, used by the writer during field work in 1921. The Basalt-barrier Lake Hypothesis is a personal communication from Dr. H. S. Summers.

Lands area. This is about nine inches in thickness, and immediately under this caked surface capping the Bad Lands material is quite soft and friable, being easily attacked by running water. Three causes may be responsible for this capping, namely:—

1. The concentration of mineral salts by evaporation as a result of percolating waters again reaching the surface by capillarity.
2. The binding action of the matted roots of vegetation.
3. The baking action of the sun at the surface.

Thus for a depth of about nine inches there is a relatively hard and resistant crust, under which, when pierced, the rock is very susceptible to the attack of erosive forces as in the manner suggested by Leach (8).

II. Preliminary Survey of Previous Hypotheses.

Regarding the mode of formation and hence the relative age of the Bad Lands material there has been some diversity of opinion. Quite a number of different hypotheses have been put forward but without much in the way of facts to justify them, and before outlining the work done on the actual Bad Lands material, it may be relevant to mention some of them for testing by actual facts discovered.

The author of one hypothesis states the age as being post-Basaltic; another makes it Tertiary.

A peculiar feature of the Tertiary around Melbourne has led to another hypothesis—the Leaching Hypothesis.² It has been noticed in places such as road cuttings, that when the Tertiary is exposed to the subaerial forces, it almost always shows bleaching to some extent at least, and is deprived of its ferruginous cement which has the characteristic brown colour. The material after the leaching out of the iron loses its compact character, becomes soft and friable and of a distinctly lighter colour—light brown to even white. This process has led to the view that the Bad Lands formation was essentially of the same age as the Tertiary marine series, and part of that series which has suffered unduly under the subaerial forces that have been greatly aided in their work of destruction by the agency of Man himself. In support of this hypothesis it was pointed out that the Bad Lands formation differed from the normal Tertiary in the almost complete absence of ferruginous material, the deposit being quite light in colour and correspondingly soft and friable, as a result of the lack of this cement, which makes the Tertiary usually hard and compact. The effective ferruginous cement is pictured as being leached out by percolating waters, which gained considerable assistance by the breaking through of the hard capping (which naturally protects

2.—See footnote page 61.

the Tertiary from denudation) by the construction of plough furrows during the land boom in the 'eighties. At that time it is said that the land on the site of the Bad Lands was subdivided and, to mark the boundaries, plough furrows were run down the slope of the hill, and that the run-off waters naturally sought these depressions, utilising them as channels. Since the hard capping and the binding of grassy vegetation were of no further avail in protecting the Tertiary below, the waters were able to scoop out deep channels in a comparatively short space of time. As then the subaerial agencies were allowed free access to a soft material, they soon leached out a large quantity of iron. In corroboration of this type of action due to weathering, attention is called to road cuttings around Melbourne which have been made comparatively recently, e.g., at La Rose, North Essendon. Here the face of the cutting is furrowed deeply and the material is bleached and looks similar in lithological character to that in the Coburg Bad Lands. It is notable that such alteration by weathering (which is almost certainly the case in these instances) gives rise to light coloured rubbly material; to some extent at least.

This hypothesis postulates that the Bad Land formation is merely the result of weathering of the normal Tertiary, such weathering being due to, and in the first instance promoted by, Man's influence in disturbing Nature's nicely balanced condition of equilibrium when the subdivisional furrows were put in during the land boom days. By upsetting this equilibrium, Man thus gave the erosive forces an opportunity to produce the great scouring out that has taken place. The subaerial forces are still extending their conquest towards the hilltop by a process of headward erosion.

The description and map given in Cook's paper (4) leads one to the conclusion that he regarded the Bad Lands as being portions of the Tertiary Marine Sands.

Another hypothesis is based upon the accumulation behind a temporary barrier. It suggests that the deposit was produced by interruption of the drainage by a basalt flow.³ Such a condition would give rise to a small lake on the site of the present Bad Lands, and in it there would be deposition of material derived from the Tertiary and Silurian.

III. Nature of the Present Investigations.

The work done in connection with this area includes the making of the mechanical analyses of the Bad Lands material and of the Tertiary associated with it and the microscopical examination of the grades so obtained, together with a field survey of the locality, based in large measure upon the results of the mechanical analyses. The mapping was rendered difficult on account of the surface being covered with grass, and the great

3.—Personal communication from Dr. H. S. Summers, Melbourne University.

scarcity of actual rock exposures. The boundaries to the E., N.E., and S. of the Bad Lands gave less trouble, but the western boundary of the Bad Lands material is exceedingly difficult to place with accuracy on account of the fact that with every rain the Bad Lands material is being washed down-hill to the west and deposited as thin hill wash, completely obliterating the junctions.

Two maps are given: one on a large scale showing the environment of the Bad Lands themselves, and a small locality plan showing the exact position of the area which has been mapped in detail. For geological boundaries outside this area I have relied upon modifications of G. A. Cook's map (4), taken from an unpublished map lent me by Mr. Singleton.

A description of the method used for the mechanical analyses is given as an appendix to this paper.

IV.—Results and Discussion of the Mechanical Analyses.

The outstanding fact brought out by the mechanical analyses is the distinctness between the normal marine Tertiary and the Bad Lands material. The figures show predominance of the silt and clay grades in the Bad Lands deposit, whereas in the Tertiary the coarse grades are dominant. The average cumulative percentage above the lowest limit of the sand grade, i.e., the sum of percentages of all material over 0.1 mm. in diameter, for the Tertiary is 86%, whereas the corresponding figure for the Bad Lands is only 25% approx. This is best brought out by the means of a graph.

The method of plotting the results of the mechanical analyses is that outlined by Holmes (6, p. 216), except that the horizontal scale adopted is not proportional to the logarithms of the diameters, but directly proportional to the square roots of the diameters. The use of the logarithm of the diameter requires the zero of diameter to be represented at infinity. The use of the square roots of the diameters gives the zero of the diameter a finite position on the graph.

Baker (2) has graphed elutriation curves by plotting the actual grade diameters. This method gives a finite zero, but where the particles differ widely in their grade sizes the length of the graph becomes far too great, so that this method is not satisfactory except in cases where the sample shows comparatively small variation in the diameters of its particles, i.e., is well graded. For the purposes of graphing, the cumulative percentage weights were added up from the tables of analyses, and these are given in Table II.

The curves for the Tertiary were found to take up their position as a distinct group on the graph, while the analyses of typical Bad Land material gave a series of curves in an area of the graph quite distinct from the Tertiary. Both series show considerable uniformity, and as the whole area under consideration is small, it was found that the position of the curve in either of these two

TABLE II. (Continued).

	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.
Clay -	99.9	100.0	100.0	100.0	100.0	100.2	100.0	100.0	100.0%
Fine Silt -	0.01 to 0.05 mm.	65.6	76.9	67.5	63.8	67.7	40.2	88.4	48.7%
Coarse Silt -	0.05 to 0.1 mm.	28.1	33.0	46.8	39.5	29.3	22.5	53.6	13.2%
Sand -	0.1 to 1.0 mm.	3.5	13.5	32.9	25.5	11.4	16.1	40.6	6.3%
Gravel -	> 1.0 mm.	1.0	6.3	11.8	2.2	1.2	6.9	13.8	1.3%
Maximum Size of Gravel	2.68	4.15	3.21	2.81	5.29	2.00	2.95	3.54	4.13 mm.
Square Root of Diameter	1.64	2.04	1.79	1.68	2.30	1.42	1.72	1.88	2.03

I.—Bad Lands about 15 inches below surface immediately beneath the hard capping.

II.—Bad Lands about 6 feet below I.

III.—Bad Lands about 10 feet below I.

IV.—Tertiary East of Bad Lands.

V.—Tertiary N.E. of Bad Lands.

VI.—Tertiary South of All-White Poultry Farm.

VII.—Tertiary S.E. of Bad Lands.

VIII.—Tertiary North of Bad Lands.

IX.—Bad Lands 18 inches below surface on slope between Kyle and James Streets.

X.—Bad Lands 18 inches below surface on slope between Kyle and James Streets.

XI.—Bad Lands 18 inches from surface in Creek Section West of Kyle Street.

XII.—Bad Lands 2 feet below XI.

XIII.—Bad Lands 4 feet below XI.

XIV.—Bad Lands 4 feet below XI.

XV.—Bad Lands on hillside between Kyle and James Streets.

XVI.—Bad Lands West of Kyle Street, 80 feet West of Creek.

XVII.—Bad Lands near the contact with basalt.

groups indicated the series to which the sample belonged. It was stated earlier in the paper that great difficulty was experienced in the separating of the two series in the field. The junctions are grass-covered for the most part, and it became necessary to be able to distinguish between the Tertiary and the Bad Lands by examination of the loose detrital material. The usual methods of mapping in the field were found ineffectual. It became necessary to use some method to separate the two series in some systematic manner in the laboratory. To this end the mineral suites in both series were examined, but they showed great similarity, and so no satisfactory distinction could be made on mineral composition except in the few places where the solid ferruginous Tertiary could be found. The only distinction found to hold for the systematic mapping was that provided by the mechanical analyses, and this led to a considerable number of analyses being made with a view to determining the lateral extent in plan of the already known Bad Lands area.

The mapping problem thus resolved itself into that of making the analysis, obtaining the curve for the particular sample and noting the group to which it belonged, and then mapping the locality in accordance with the data so obtained.

Prior to this work being undertaken, the Bad Lands were considered to exist only as far west as the neighbourhood of Kyle Street, but this work has resulted in this deposit being extended across the small tributary valley, and right over to the basalt. This further information lends colour to the last and most probable hypothesis for consideration—namely, that the deposit was formed by a deposition in a lake dammed back by the basalt.

Since the work has been completed, the writer has had the view strengthened that the westerly extension is considerably west of Kyle Street by hearing from an old resident that he remembers the time when there were canyons to the west of Kyle Street exactly similar to those now restricted to the east of Kyle Street, and that he was employed by the landowner to shift the greater amount of the deposit by means of drays.

V. Results of the Microscopical Examination.

The disintegrated material obtained from the elutriator was examined under the microscope using clove oil as a mounting medium, its index of refraction being similar to that of Canada balsam, 1.544. The results of the microscopical examination showed the similarity in mineral content of the Tertiary and Bad Lands. The mineral assemblage is found to be largely identical also with that of the Silurian as given in Langford's paper (7).

It was found early that the mineral content showed an overwhelming preponderance of the minerals quartz and felspar, so much so as to make the discovery of the less common minerals difficult. To facilitate the search for these accessory minerals large samples were treated (9) with bromoform (S.G. 2.84) in

order to float off the lighter quartz and felspar and leave the heavy residue concentrated for closer examination.

The most striking essential difference between the Tertiary and the Bad Lands material, however, lies in the presence of the limonitic cement in the Tertiary, while the Bad Lands are distinctly lacking in this constituent.

The minerals common to both the Tertiary and Bad Lands are as follow:—

Quartz.—In great abundance, occurring in irregular grains without crystal boundaries. Low refractive index, no cleavage and many showing 1st order yellows under polarized light. Many good uniaxial interference figures and of positive sign.

Felspar.—Also greatly abundant, but showing much cloudiness due to weathering. Biaxial, R.I. low, and showing low polarization colours. A few show somewhat vague indications of lamellar twinning, and may be plagioclase.

Tourmaline.—This is a fairly abundant accessory, occurring in rectangular grains, with refractive index higher than quartz. Pleochroism strong, and with straight extinction. Uniaxial figures and negative sign. The grains are quite free from alteration.

Topas.—R.I. higher than quartz, straight extinction. Biaxial and with basal cleavage. Occurs in rounded grains.

Zircon.—Many grains show crystal faces. High R.I., and showing whites of high order. Uniaxial. This mineral is common as an accessory.

Rutile (probably).—Reddish brown, rounded grains, with high R.I., and with high polarization colours. Uniaxial.

Iron Ores.—Occurring as minute black opaque grains of irregular shape, probably magnetite and ilmenite.

Micas.—Biotite occurs rarely, as crystals with frayed ends and basal cleavage, markedly pleochroic and with high polarization colours. There are also colourless, ragged-ended crystals, with characteristic cleavage of the micas, high colours and biaxial figure, and hence probably muscovite.

Andalusite.—Occurs in rounded prismatic grains, with inclusions present. The mineral was colourless, and so showed no pleochroism. Cleavage present, but not very distinct. R.I. fairly high, low polarization colours. Biaxial and showing straight extinction.

Of the minerals mentioned quartz is by far the most important in quantity, the felspar being very common but subordinate to the quartz. Of the minerals present in small amounts the most conspicuous is the tourmaline, although zircon is quite common, the others mentioned being quite subordinate, while the micas are only rarely found.

The limonite in the Tertiary occurs as a brown cementing material coating the grains of other minerals. The friable nature of the Bad Lands may be attributed to the lack of this ferruginous cement.

VI. Summary of the Evidence obtained at Coburg.

1. All three series (Silurian, Tertiary, and Bad Lands) have similar mineralogical composition with the notable exception of the presence of limonitic cement in the Tertiary. When this limonite becomes leached out, as it does on weathering, the Tertiary assumes the appearance of the Bad Lands.

Minerals present include quartz, felspar (perhaps including plagioclase), tourmaline, rutile, topaz, zircon, iron ores, micas, and probably andalusite.

2. The mechanical analyses show the Bad Lands and Tertiary to be distinct, i.e., the Tertiary is coarse and the Bad Lands fine.

3. The Bad Lands material is homogeneous in grain size in vertical sections excepting for the presence of the thin basal conglomerate and the immediate surface soil.

4. The Bad Lands material is visibly unconformably overlying the Silurian, but no section can be seen at Coburg showing Tertiary and Bad Lands in stratigraphic contact, although the mapping demonstrates their unconformable relations.

5. The Silurian occurs close to the surface near the top of the hill, but further down the hill the thickness of the Bad Lands deposit becomes 12-15 feet.

6. The Bad Lands material shows bedding, and may be considered to be *in situ*.

7. The Tertiary is ferruginous: the Bad Lands not ferruginous.

8. The Bad Lands material is unconsolidated, while the Tertiary normally is consolidated.

9. No fossils have so far been obtainable from either series at Coburg. A doubtful sponge spicule was noted in the microscopical examination of the sands from the Bad Lands.

In examination of the Bad Lands material under the microscope organic remains were found. These were diatoms belonging to the genera *Fragillaria*, *Melosira* and *Synedra*, but it was found that they came in with the water during the elutriation process and are therefore valueless as fossil evidence concerning the Bad Lands.

10. Pebbles in the basal conglomerate of the Bad Lands include some of the material belonging to the marine Tertiary. It follows that the Bad Lands are post-Tertiary in age.

11. The Bad Lands material is notably free from basaltic detritus. There is an absence, as far as it is observable, of basaltic pebbles associated with the Bad Lands, although there is a great abundance of pebbles from both Tertiary and Silurian. However, near the western limit of the deposit the material includes detritus derived from the basalt.

VII. Discussion of Hypotheses in the Light of New Evidence.

With this evidence it is possible to review the two hypotheses mentioned at the beginning of this paper. The first is the hypothesis which postulates that the Bad Lands material was produced by leaching from the original Tertiary *in situ*, aided by Man's influence in piercing the hard protective capping. Although the mechanism whereby the water got down below the hard capping is given as due to the putting in of plough furrows along subdivisional boundaries in the boom period, yet such procedure is not likely. What probably happened and realised the same ultimate result even more effectually was that the upper surface was shovelled off and carted away on account of the builders' great demand for this particular kind of material constituting the hard capping. There is abundant surface indication that such illicit practices occurred before the subdivisional survey was made. The building boom was flourishing in 1885-6, and this hard capping was probably removed at this time. The fact that the survey took place subsequently in 1888 is in accord with these considerations.

Certain of the evidence obtained at Coburg agrees with the leaching hypothesis, e.g., the mineralogical similarity between the Tertiary and the Bad Lands deposit, the absence of limonite in the latter being pictured as due to the leaching out of the cementing medium. This accords also with the unconsolidated friable nature of the Bad Lands, the absence of fossils and the persistency of its faint bedded nature.

The objections are mainly those appearing on inspection of the mechanical analyses. There should be no basal conglomerate containing rounded Tertiary pebbles. If the Tertiary marine deposit were the parent rock undergoing leaching, the coarser grades should still be present. The simplicity of this hypothesis is commendable, but while it is on this account interesting, the facts shown by the mechanical analyses are difficult of explanation. The lack of the sand grade (1.0—0.1 mm.) in the Bad Lands is considered to show the distinctness between the Bad Lands material and the Tertiary. The question may well be asked, why is it that the Bad Lands deposit lacks the coarse sand grade percentage which characterizes the Tertiary? The mechanical analyses show the percentages down to the lower limit of the sand grade to be 25% and 86% for the Bad Lands and Tertiary respectively.

The other hypothesis for consideration is that which postulates that the Bad Lands material was deposited in a lake formed subsequently to the Newer Basalt, behind a barrier caused by one of these flows. Such a mechanism would readily accord with the mineralogical similarity between the three series—the limonite probably disappearing in solution as in the last hypothesis. The

reason that there is a lack of the coarser grades in the Bad Lands may be that the Silurian material and only the *finer* grades of the Tertiary were carried into the lake, the currents being not strong enough to transport the coarser grades. This would give a higher sand percentage in the Tertiary than in the Bad Lands.

The site of the lake was probably determined by the presence of the old valley mentioned by Cook (4). This old valley must have been cut down right through the Tertiary to the Silurian beneath, before the deposition of the Bad Lands material commenced. This is shown by the fact that the Bad Lands is clearly resting directly on the Silurian, and the basal conglomerate of the Bad Lands Series contains pebbles unmistakably belonging to the Tertiary.

Such a deposit as the Bad Lands is like a recent lake deposit, being unconsolidated, since it has never had compression due to superincumbent rock. The uniformity with the Silurian is readily explained, and so also is the basal conglomerate with its rounded pebbles of the Tertiary. The homogeneity of the Bad Lands material in vertical section is satisfied, and so also is the slight bedded nature of the deposit.

VIII. Conclusion and Acknowledgments.

It is concluded, so far as can be gleaned from the evidence at present obtained at Coburg, that the Bad Lands are certainly younger than the marine Tertiaries, and also very probably the result of deposition of detrital material from the neighbouring Tertiary and Silurian in a lake formed in post-Newer Basaltic times.

In conclusion, the writer wishes to gratefully acknowledge his indebtedness to Prof. Skeats for much valuable criticism of the work in its various stages; to Dr. Summers, for much helpful discussion of the problems which have arisen from time to time; and to Mr. Singleton, M.Sc., and Dr. Stillwell, for useful suggestions in the laboratory work.

IX. Appendix.—Description of the Apparatus and Method used in making the Mechanical Analyses.

The mechanical analyses were done by the method of elutriation for the three finest grades, viz., clay, fine silt and coarse silt (i.e., below 0.1 mm.), while coarse grades, gravel and sand, were separated by wet sieving in a circular mesh sieve.

The form of elutriator used first was similar to that described by Crook (5), but this was later discarded in favour of a single-vessel on account of the difficulties in working the particular vessels in use. The single-vessel type used is similar to that described by Holmes (6), where Prof. Boswell's description (3) is quoted. Two of these elutriators were used; one of large diam-

eter, about 8 inches, for estimation of the clay grade, and another of approximately 3 inches diameter for the fine silt and the coarse silt grades.

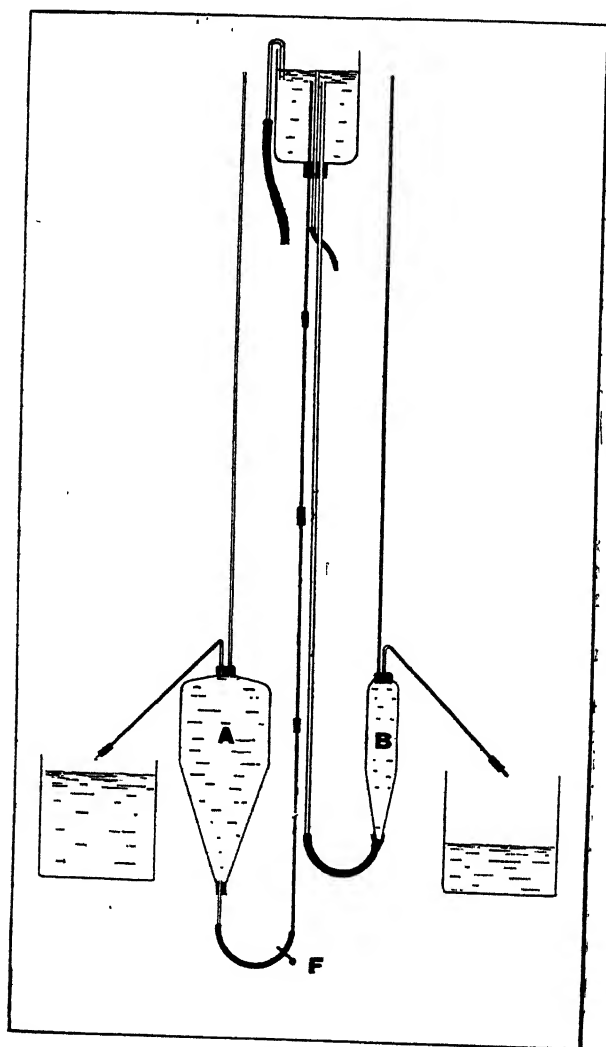


FIG. 2.

The internal diameter of the vessel B (about 3 inches) was determined by measuring the volume of water discharged while the level of the water in the vessel fell through a known height. Then the diameter thus found was used to determine the rate of outflow from the vessel in order to give the required velocity of

upward flow within the vessel (1.79 mm. per sec. for fine silt between the limits 0.01 and 0.05, and 7 mm. per sec. for coarse silt between 0.10 and 0.05 mm.). Having a reservoir supplying water under constant head and a jet of suitable size, about 1 mm., the screw clip is opened and adjusted by trial and error until the calculated rate of outflow is obtained for one particular jet. To find the required height in the manometer the method of graphing used by Baker (1) was found to be very satisfactory. The height of the column in the manometer is then marked so that for future determinations all that is necessary to obtain that particular rate of flow is to use the same jet and open up the screw clip until the manometer column reaches this point. In this way two different rates were marked—one to run off the fine silt and the other to run off the coarse silt. The larger clay elutriator A (about 8 inches diameter) was treated in the same way and adjusted to give an upward flow of 0.15 mm. per sec. The height of the water level in the manometer was then marked as before to facilitate regulation for the same flow in future determinations.

It was found that though the height in the manometer tube appeared stationary, yet after a space of two or three hours the level would show movement. As it is desirable to be able to allow the elutriation process to go on without attention, any such variation is unsatisfactory. This variation was overcome by using a small outlet feed pipe, the maximum capacity of which was scarcely greater than that required by elutriation at 0.15 mm. per sec. through the vessel A. Under these circumstances the controlling clip F needed only slight adjustment, and the flow was found to remain steady. A rubber inlet pipe was first used, but was discarded in favour of glass of similar bore. Under these conditions the manometer level was found to be quite stable for long periods.

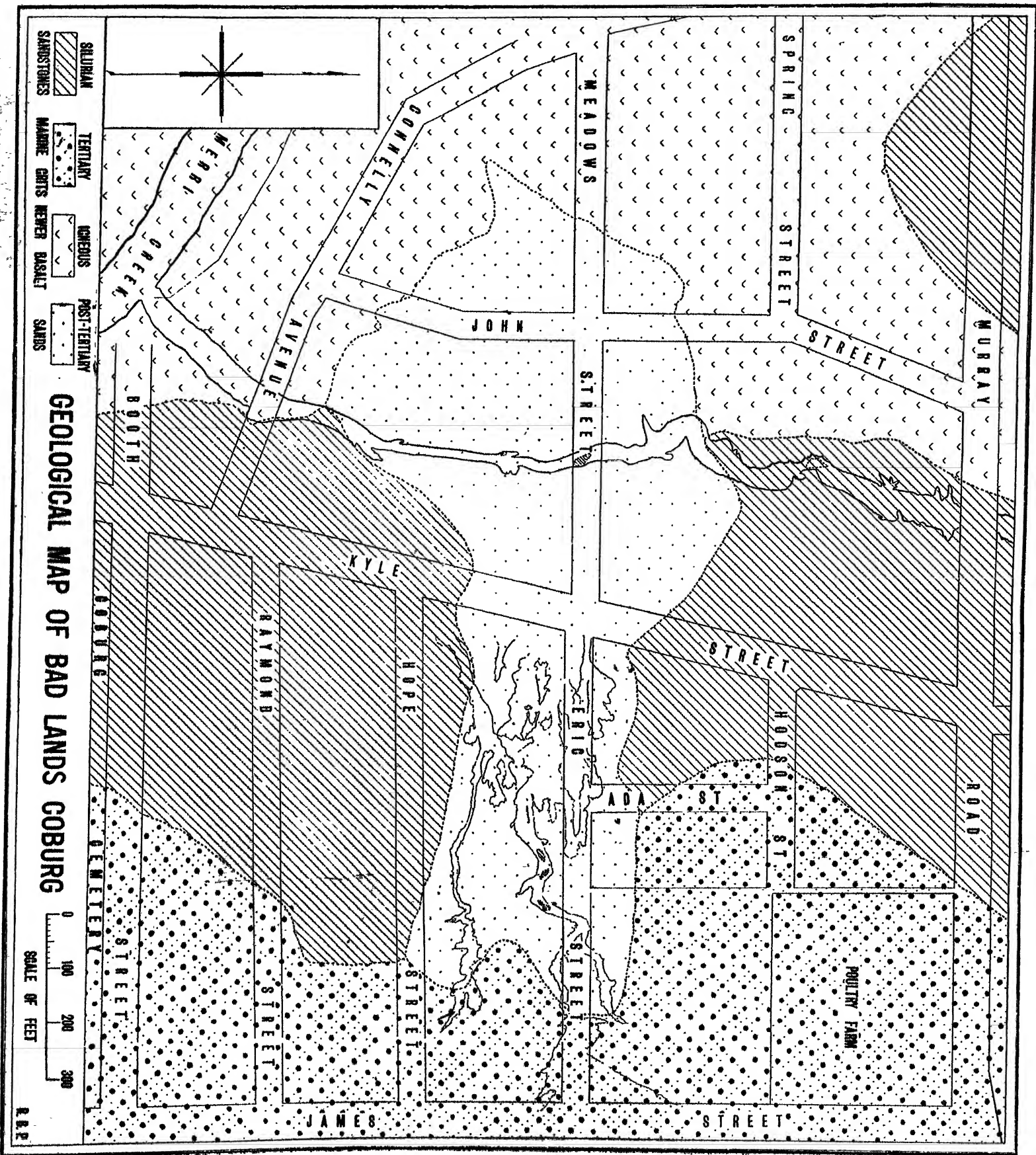
The method of calculating the required rate of flow from the figures 0.15 mm. per sec. for fine clay up to 0.01 mm. in diameter, 1.79 mm. per sec. for fine silt up to 0.05 mm., and 7 mm. per sec. for coarse silt up to 0.10 mm. diameter, gives rates of flow which bring over grades which are only approximately of the stated diameter. The maximum diameter of the particles actually coming over for each grade was measured under the microscope, and the corrections made for each of the grades were applied in the plotting of the curves in the graph. For example, it will be noted on Plate IX. that the ordinate representing the actual grade run off, is displaced a little from the ordinate representing the grade calculated to run off, and the plotting is done on these displaced ordinates, which are shown in broken lines. Having thus calibrated the particular apparatus in use the mechanical analysis may be proceeded with.

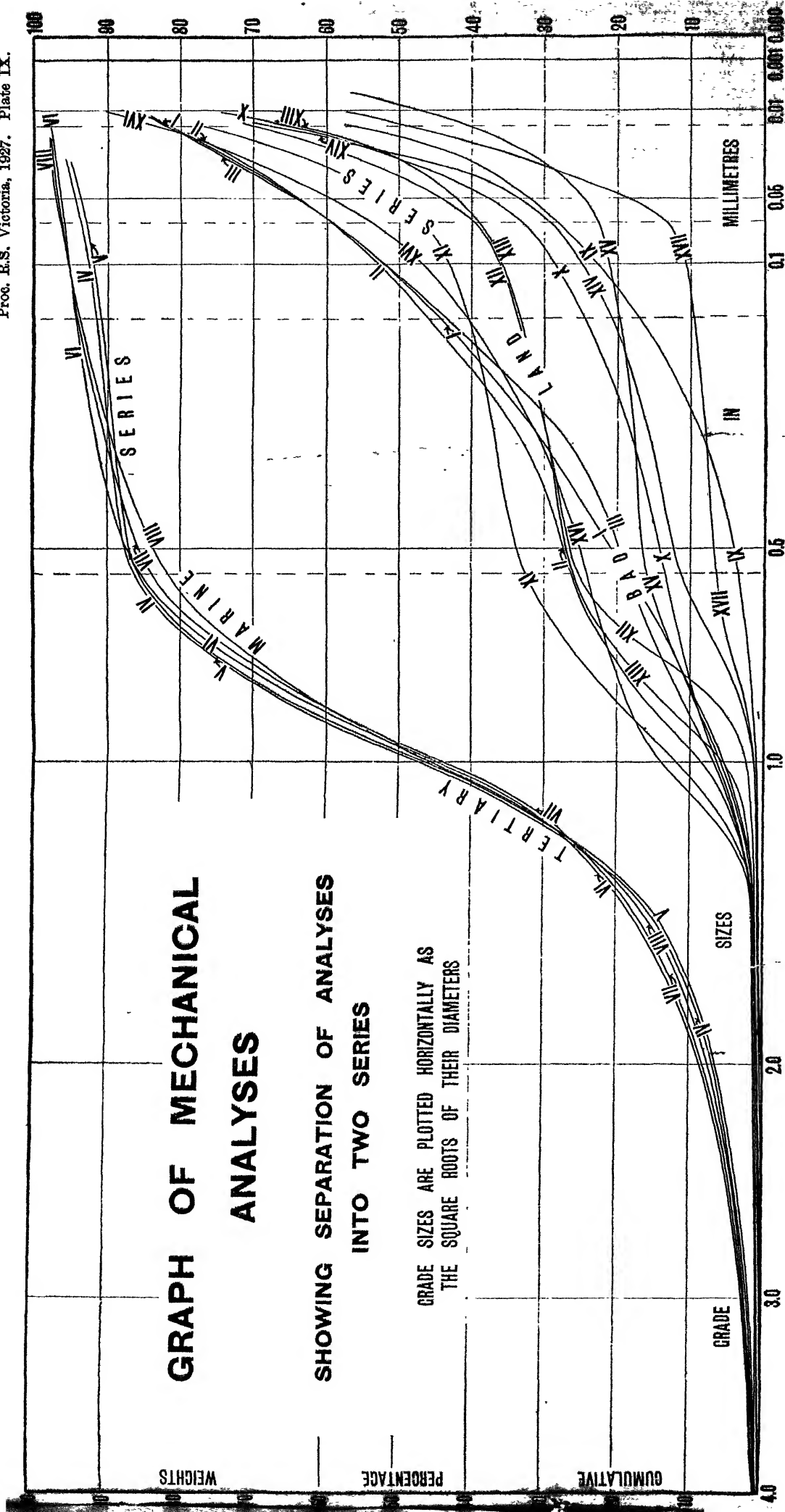
A sample of the Bad Lands material weighing several kilograms, after being air-dried on a tray, was quartered down to a sample of 15 to 25 gms., and this was placed in a tared weighing

bottle and dried as far as possible at 110°C . A weighing bottle must be used on account of the hygroscopic nature of the fine clay forming part of the material. After weighing, the sample must be prepared for elutriation by disintegration into the grain sizes in which it was laid down in the original sediment. On this account no hard pestling is permissible. It was found satisfactory to plunge the weighed material at 110°C . into a beaker of cold water, whereupon the small clods fall away into powder. Complete disintegration is promoted by warming gently to a boil, and, after cooling, by the addition of a little ammonia to deflocculate the clay.

Then with the clay elutriator A half full of water, wash the prepared sediment into it. Fill the elutriator completely, allowing time to elapse for all grades but the clay to settle below the uniformly wide part of the vessel. Start the water flowing at the required speed according to the manometer, as calibrated with the particular jet for running off the finest grade, namely, the clay (less than 0.01 mm.). The clay will be run off continually, leaving behind the three other grades, sand, silt and gravel. The conclusion of the running off of any particular grade is known to be complete when the outlet water is clear and quite free from suspended particles. Difficulty was experienced in estimating the clay. Three methods, all more or less direct, were tried, but none was completely satisfactory. The first was by evaporating down the complete volume of clay water. This was a very tedious, long and messy process requiring much attention, and thus found to be very unsatisfactory. An alternative tried was to evaporate down an aliquot part of the whole volume of clay water. This involves accuracy in measuring the volumes, as the clay water may be 15-20 litres or more, and such a bulk introduces error. The third method was that of precipitating all the clay by the addition of the electrolyte (ferric chloride) and subsequent filtration. The very large volume of liquid is too much to deal with, and the precipitation is not as complete as could be desired. After trying these methods it was found more expedient to estimate the clay indirectly.

The weights of gravel, silt and sand were added together, and subtracted from the weight of the sample, thus giving the weight of the finest grade (clay). As a check against this the elutriator was discharged at the conclusion of running off the clay and the weight of (sample minus clay) directly found by weighing. After making this check the (sample minus clay) was returned to elutriator B, and the flow regulated for fine silt. After the fine silt had been completely run off the elutriator was discharged, and the coarse silt, sand and gravel weighed together. This coarse silt, sand and gravel is then placed in elutriator B, and the flow regulated for coarse silt. This runs the coarse silt off, and leaves the sand and the gravel in the elutriator. The elutriator is then discharged into a 1.0 mm. circular mesh sieve, and the





sand passes through, leaving the gravel on the sieve. These two grades were then dried and weighed separately. In the case of the estimation of the silt and the sand there is no difficulty experienced since these two grades will subside relatively quickly to the bottom of the vessels, and the supernatant liquid can be decanted off quickly. After all the liquid possible is removed by decantation and siphoning, the tared beaker is dried in the oven, cooled and weighed.

Analyses were made of the Bad Lands material in this way, but the ferruginous Tertiary had to be treated with acid for the removal of iron, which cements the grains together, before the mechanical separation in the elutriator.

The apparatus described above has been used successfully in the Geological Department of the University of Melbourne for the systematic separation into grades of the abrasive powders used in the preparation of polished surfaces of opaque minerals for microscopical examination by reflected light, and for grinding of thin rock sections.

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ART. X.—*Australian Curculionidae of the Subfamily
Gonipterides.*

By ARTHUR M. LEA, F.E.S.

[Read 9th December, 1926.]

This subfamily of weevils appears to be confined to Australia, where most of the species feed on eucalyptus twigs and leaves. As adults many of them drop on the least alarm, but others cling so tightly that some force is needed to detach them, not infrequently one or more legs being broken in the operation. *Iptergonus cionoides* is abundant in some years near Sydney, but specimens seldom fall into the umbrella from plants beaten over it. Two characters appear to be constant in the subfamily.

1. A dense pad-like mass of clothing at the base of the prothorax, normally concealed when that part is closely applied to the elytra.
2. Each side of the metasternum abruptly vertical over the hind coxa, appearing as if with a conspicuous tubercle from the side.

All the genera contain species that are more or less densely covered with a meal, that is often of a rusty-red or ochreous colour. The meal often becomes greasy, and the grease holds dust, so that specimens often have a dirty appearance, and normal markings become obscured; occasionally the meal becomes caked, and conceals both derm and scales. On washing with chloroform, benzine, or other grease-absorbing liquids, the grease and meal are easily removed, but cleaned specimens often look very different from those on which the meal is in perfect condition. Washed specimens usually have more prominent eyes, owing to the removal of the meal that is normally present behind them. It is in fact difficult to keep the meal in good condition, and it is often left only in the punctures and other depressed spaces. I have often found it impossible to remove the grease without at the same time removing the meal. Where the necessary specimens are available it is always desirable to select two, agreeing as closely as possible, and to wash one of them with chloroform, etc. Scales and fascicles that on many specimens appear more or less rusty, after washing usually become snowy-white or silvery.

On most species of the subfamily the middle of the third and fourth segments of the abdomen is polished and glabrous. The second joint of the funicle appears to be usually longer than the adjacent ones.

In *Gonipterus*, *Oxyops* and *Iptergonus* many of the species (probably all of them) may be found in four apparent forms:—

1. Densely covered with a meal varying with the species from almost white to yellow, red, and muddy-brown, and partly or entirely concealing the derm and scales. Such specimens are usually in perfect condition when taken, but are especially liable to become greasy with age.
2. Irregularly covered with meal, mostly in depressed parts. These are usually specimens killed without being placed in liquids, and which, owing to a certain amount of rubbing have meal partly removed. With age they tend to become greasy, and the grease may discolour the meal.
3. No meal present, usually specimens that have been in alcohol for some time, when the whole of the meal is removed. Such specimens seldom become greasy, and the sculpture (but not the clothing, which is sometimes affected) is generally in perfect condition for examination. In weak alcohol, or after prolonged immersion, the scales may be stained or largely abraded.
4. No meal present, and often no scales on the upper surface, but the derm with a varnished or leaden appearance. This is apparently due to old age, and living specimens may be seen with it, sometimes in copulation with mealy ones. It occurs in *Catasarcus* and other weevils; and is not altered by washing with chloroform. In *Syarbis* a somewhat similar incrustation may be occasionally noticed, but may be removed. I have not seen it in *Pantoreites* or *Prophaesia*, although mealy specimens of both genera may be taken.

The punctures especially vary in appearance with the density of the meal and clothing, and on greasy and mealy specimens even large ones are often completely hidden. It is not always easy to connect the various forms, and in consequence some synonymy has resulted. With greasy, dirty or badly abraded specimens, it is often difficult or impossible to determine the species, and in collections it is desirable that many such should be left unnamed. Many specimens, however, may be improved in appearance by washing with chloroform.

Although some of the species, especially of *Gonipterus*, are very unsatisfactory, the genera (except that a few species are intermediate between *Gonipterus* and *Oxyops*) are easy of recognition, as is evidenced by the following table:—

A. Tarsi without claw-joint	<i>Syarbis</i>
AA. Tarsi with claw-joint.	
B. Club continuous with funicle	<i>Bryachus</i>
BB. Club much wider than funicle.	
C. Rostrum long and comparatively thin ..	<i>Prophaesia</i>
CC. Rostrum short or comparatively short.	
D. A conspicuous posthumeral tubercle on the sub-	
marginal interstice on each elytron	
	<i>Gonipterus</i>

- DD. Without such a tubercle.
 E. Eyes not prominent *Pantoreites*
 EE. Eyes very prominent.
 F. Intercoxal process of mesosternum
 pointed in front *Oxyops*
 FF. Process rounded in front *Iptergonus*

Notes on Table.

D. The posthumeral tubercle is occasionally absent from *Gonipterus*, but on such species the intercoxal process of the mesosternum is not subacutely produced as it usually is in *Oxyops*. On many species of *Oxyops* there is a cluster of granules at the position of the tubercle of *Gonipterus*, but not a strong isolated tubercle. Pascoe considered that *Oxyops* and *Gonipterus* were not both needed, but there are many species of both that may be readily identified generically.

EE. On several species of *Oxyops* the eyes are but little more prominent than in *Pantoreites*, but the two genera are abundantly distinct.

Minia not included as unknown to myself, and its subfamily doubtful.

Following is a list of the species, with their known geographical distribution.

Oxyops, Schon.

<i>alphabetica</i> , Lea	Q., S.A., C.A.
<i>amplipennis</i> , Lea	N.S.W.
<i>arcifera</i> , Pasc.	Q.
<i>aulica</i> , Pasc.	Q., N.T.
<i>interrupta</i> , Blackb.	
<i>bilunaris</i> , Pasc.	Q., N.S.W., V., S.A.
<i>calida</i> , Pasc.	N.W.A.
<i>clathrata</i> , Boh.	S.A.
<i>concreta</i> , Pasc.	Q., N.S.W.
<i>crassirostris</i> , Pasc.	V., S.A., W.A.
<i>crassicornis</i> , Mast.	
<i>decipiens</i> , Lea	Q.
<i>excavata</i> , Boi.	Q., N.S.W.
<i>favosa</i> , Boh.	
<i>farinosa</i> , Pasc.	V., S.A., W.A.
<i>fasciata</i> , Boi.	Q., N.S.W., V., T., S.A., W.A., N.W.A., N.T., C.A.
<i>obliquata</i> , Boh.	
<i>parallela</i> , Blackb. var.	
<i>fasciculata</i> , Redt.	Q., N.S.W., V., S.A.
<i>maculata</i> , Blackb.	
<i>florea</i> , Pasc.	W.A.
<i>frenchi</i> , Lea.	Q.
<i>gemella</i> , Pasc.	V., S.A., W.A.
<i>griffithi</i> , Lea	Q.
<i>grisea</i> , Lea	Q.
<i>hopéi</i> , Boh.	Q., S.A.
<i>hyperoides</i> , Pasc. (<i>Gonipterus</i>)	Q.
<i>simplex</i> , Lea	
<i>irrasa</i> , Pasc.	Q., N.S.W.

<i>marginalis</i> , Pasc.	Q., N.T., N.W.A.
<i>armata</i> , Blackb.	
<i>mastersi</i> , Pasc.	N.S.W., S.A., N.W.A.
<i>meles</i> , Pasc.	W.A.
<i>memnonia</i> , Pasc.	W.A.
<i>modesta</i> , Lea	N.S.W., V.
<i>modica</i> , Blackb.	N.T.
<i>mucronata</i> , Lea	Q.
<i>multidentata</i> , Lea	N.W.A.
<i>niveosparsa</i> , Pasc.	Q.
<i>nodicollis</i> , Lea	Q.
<i>pallida</i> , Lea	N.W.A., N.T.
<i>parvicollis</i> , Lea	Thursday I.
<i>pictipennis</i> , Blackb.	V., S.A., W.A.
<i>serricollis</i> , Lea	
<i>placida</i> , Blackb.	N.S.W.
<i>posticalis</i> , Lea	S.A., W.A., C.A.
<i>pruinosa</i> , Pasc.	Q., N.W.A.
<i>reticulata</i> , Boi. (<i>Gonipterus</i>)	N.S.W., S.A.
<i>cancellata</i> , Boh.	
<i>rufa</i> , Lea	N.S.W., V.
<i>rutila</i> , Pasc.	W.A.
<i>scabra</i> , Lea	Q.
<i>scabrosa</i> , Boi. (<i>Gonipterus</i>) .	Q., N.S.W.
<i>squamulosa</i> , Boh.	
<i>scoparia</i> , Lea	V., S.A., W.A.
<i>sepulchralis</i> , Pasc. (<i>Goni-</i>	
<i>terus</i>)	S.A.
<i>sicca</i> , Blackb.	N.T.
<i>soror</i> , Lea	Q., N.W.A., C.A.
<i>sparsuta</i> , Pasc.	W.A.
<i>spencei</i> , Blackb.	N.T.
<i>tuberculata</i> , Perr.	Australia
<i>turbida</i> , Pasc. (<i>Gonipterus</i>)	N.S.W., V., S.A., N.W.A., N.T.,
<i>obscura</i> , Blackb. (<i>Medi-</i>	C.A.
<i>casta</i>)	
<i>minuscula</i> , Lea	
<i>uniformis</i> , Lea	
<i>vacillans</i> , Lea	Q., S.A., W.A.
<i>vitiosa</i> , Pasc.	Q.

Gonipterus, Schon.

<i>balteatus</i> , Pasc.	Q., N.S.W., V., S.A.
<i>cinnamomeus</i> , Pasc.	Q.
<i>citriphagus</i> , Lea	W.A.
<i>crassipes</i> , Lea	Q., N.S.W.
<i>exaratus</i> , Farhs.	Australia
<i>excavifrons</i> , Lea	Q., N.S.W., S.A.
<i>ferrugatus</i> , Pasc.	Q., N.S.W.
<i>geminatus</i> , Lea	N.S.W.
<i>gibberus</i> , Boi.	N.S.W., V., T., S.A.
<i>lateritius</i> , Blackb. (<i>Oryops</i>)	W.A., N.W.A., N.T.
<i>lepidotus</i> , Gyll.	Q., N.S.W., V., T.
<i>notographus</i> , Boi.	Australia
<i>pulverulentus</i> , Lea	N.S.W., V.
<i>rufus</i> , Blackb.	Q., N.S.W., V., T.
<i>scutellatus</i> , Gyll.	Q., N.S.W., V., T.
<i>suturalis</i> , Gyll.	N.S.W., V., S.A.
<i>xanthorrhoeae</i> , Lea	N.S.W.

Bryachus, Pasc.

squamicollis, Pasc.	Q., N.S.W., V., S.A., W.A., N.W.A., C.A.
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Iptergonus, Lea.

aberrans, Lea (<i>Oxyops</i>) . . .	W.A.
lbifurcatus, Lea	Q.
cionoides, Pasc. (<i>Gonipterus</i>)	N.S.W.
niveopictus, Lea	N.S.W.

Pantoreites, Pasc.

<i>P. breweri</i> has been transferred to <i>Lycosura</i> .	
arctatus, Pasc. (<i>Oxyops</i>) . .	V., S.A., W.A., C.A.
brevicollis, Lea	
cretatus, Pasc.	W.A.
illuminatus, Lea	V., T., S.A.
major, Lea	V., S.A.
micans, Lea	W.A.
scenicus, Pasc.	N.S.W.
trilinealbus, Lea	N.S.W.
trivirgatus, Lea	W.A.
virgatus, Pasc.	S.A., W.A.
vittatus, Pasc.	N.S.W.

Prophaesia, Pasc.

albilatera, Pasc.	S.A.
<i>Pantoreites longirostris</i> , Lea.	
florea, Pasc.	W.A.
confusa, Pasc.	T.
cretata, Pasc.	V., S.A.

Syarbis, Pasc.

alcyone, Lea	N.S.W., V., T.
deyrollei, Roel. (<i>Acroteriasis</i>)	Australia
emarginatus, Roel. (<i>Acroteriasis</i>)	
eucalypti, Lea	W.A.
fasciculatissimus, Lea . . .	N.T.
gonipteroides, Pasc.	N.W.A.
goudiei, Lea	W.A., N.W.A., C.A.
haagi, Roel. (<i>Acroteriasis</i>)	V., S.A.
plumbeus, Lea	N.S.W.
sciurus, Pasc. var.	
nervosus, Pasc.	Q., N.S.W.
niger, Roel. (<i>Acroteriasis</i>)	N.S.W.
plumbeus, Lea	
nubilus, Roel. (<i>Acroteriasis</i>)	Q., N.S.W., V., N.T.
brevicornis, Lea	
pachypus, Pasc.	Q.
porcatus, Lea	N.S.W., S.A., W.A.
pulchellus, Lea	W.A.
pulchripennis, Lea	N.W.A.
punctipennis, Roel. (<i>Acroteriasis</i>)	Australia

sciurus, Pasc.	W.A., N.W.A.
semilineatus, Pasc.	W.A.
simulans, Lea	N.S.W.
subnitidus, Roel. (<i>Acroteri-</i> <i>asis</i>)	Australia

Minia, Pasc.

opalescens, Pasc.	N.S.W.
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I have to thank Mr. Gilbert J. Arrow and Dr. G. A. K. Marshall, of the British Museum, for information as to some types in that Institution.

OXYOPS RETICULATA, Boi.

Two specimens of this species, from the Blue Mountains, are slightly smaller (9 mm.) than usual, and have the elytra with thin scales forming a fairly distinct fascia at the summit of the apical slope; on many specimens this fascia is not traceable, and it is usually very feeble. Two specimens of normal size, from Sydney, have the prothoracic granules and elytral punctures larger than usual, and the elytra have two subapical tubercles that are hardly indicated on others.

OXYOPS SCABROSA, Boi. (*Gonipterus*).*O. squamulosa*, Boh.

The description of *O. scabrosa*, an unusually lengthy one for Boisduval, makes it practically certain that it was founded upon the same species as *O. squamulosa*, over which it has precedence.

OXYOPS FASCIATA, Boi.

O. parallela, Blackb. var.

The type and a co-type of *O. parallela* are in the South Australian Museum, and I think they should be regarded as representing a variety of *O. fasciata*; they differ from most specimens of that species in the derm being of a dingy reddish-brown, instead of jet black (when the meal has been removed), and the third interstice is more strongly ridged, or with an elongated tubercle, near the base, and again about the summit of the apical slope. It has been already noted (1) that the length given in the original description should have been four lines, not two. A specimen from Queensland (Somerset), probably represents another variety; it is smaller (7 mm.) than usual, and has the tips of elytra more conspicuously mucronate; is of a dingy brown (except that the pronotum is blackish), and has a greater area about the scutellum clothed with whitish scales; but the postmedian fascia is normal. In the Queensland Museum there are three specimens, from Brisbane, that are decidedly wider than is usual in *fasciata*. In the South Australian Museum there is a specimen of *fasciata*

from Charters Towers, in which the colour is almost identical with the types of *parallela*, but the third interstice is normal. A specimen from Oodnadatta is normally dark, but has the elevations of the third interstice even more pronounced than on *parallela*. The scales composing the postmedian fascia also vary; on some they are shorter and fully twice as wide as on others. Cleaned specimens, with snowy-white scales, look very different from others densely covered with a rusty-looking meal, although this seems to be more easily lost than on many other species.

OXYOPS CLATHRATA, Boh.

The description of this species, except for the rostrum, reads as if it might have been founded upon a specimen of *O. farinosa*, from which the meal had been entirely removed (by immersion in alcohol, etc.). The rostrum, however, was described as unicarinate, and in *farinosa* it is tricarinate, the median carina well-defined, the others feeble and oblique. If the names are synonymous *O. clathrata* has priority. I have seen the name applied to *O. reticulata*, but that can hardly be correct, as each elytron has two tubercles on the apical slope.

OXYOPS PRUINOSA, Pasc.

Specimens of this species in perfect condition are so densely covered with ochreous-grey or ashen meal that the derm is concealed, except that a few granules and the median carina are visible on the pronotum; on being partly removed the alternate interstices of the elytra show up conspicuously, but the punctures usually remain full; on washing the elytra to remove the meal, the alternate interstices are seen to be distinctly elevated and granulate, although not throughout; the basal half has large punctures, often ringed with granules, and in places there are slight granulate elevations connecting the raised interstices; posteriorly, however, the elevations (except for a tubercle on the fifth interstice) decrease, and the punctures become smaller; there are numerous minute scales on the elytra that are normally concealed. Of this species I wrote to Mr. Arrow that "Blackburn and I separately identified the same species as *pruinosa* Pasc.; his specimens were almost completely covered with meal, mine were partly cleaned, and I washed one with chloroform to remove the whole of the meal. These specimens look very different. Do you think from comparison of the types, that it is the same as *calida*? Both are large, from Nicol Bay, and from the descriptions I imagined they might be the same with the clothing and meal differently preserved." In reply Dr. Marshall wrote: "The differences between *calida* and *pruinosa* are not due merely to the efflorescence. The unique type of *calida* is a female, and differs from the unique male of *pruinosa* in being distinctly broader; the elytra have more prominent humeral angles, and on each there are two slightly raised oblique lines, one at about the middle and the other behind;

on the dorsal surface all the scales are slightly but constantly narrower; the mesosternal process is longer and sharper; and the apical mucro on the hind tibiae is shorter. These may all be individual or sexual differences, but it would be unwise to unite the species until this has been confirmed by examination of more material. A female in the British Museum from Alexandria, identified by you as *pruinosa*, has the elytra somewhat more elongate than in *calida*, with the humeral angles much sharper, and the scales are much longer and thinner, being practically setiform. This seems less likely to be the true female of *pruinosa* than is *calida*. If not a distinct species, it must be at least a well marked subspecies. But it is difficult to reach a decision without much more material." In an additional note Dr. Marshall wrote, "*O. calida*, female, is extremely close to *pruinosa*, male, and may be only the other sex; the sculpture is coarser, the raised areas being rather more raised; the scales on the elytra are rather narrower, the scales on the venter are uniformly narrow, whereas in *pruinosa* there are narrow and broad scales intermingled."

OXYOPS FARINOSA, Pasc.

In previously commenting on this species (2) I stated that the tibiae were "entirely without the numerous small teeth so common in the subfamily." This is incorrect: there are some small teeth there, but they are normally almost or quite concealed by the clothing. On washing with chloroform the meal may be entirely removed, when the body is seen to be entirely deep black, and clothed with rather long setae, except on the elytra, where the clothing is very short. On cleaned specimens (as on many others of the genus) the true fourth joint of the tarsi appears as a minute basal portion of the claw-joint. The species occurs in many parts of Western Australia, South Australia (including Kangaroo Island), and Victoria.

OXYOPS AULICA, Pasc.

O. interrupta, Blackb.

A large species, extending to 18 mm., although usually somewhat smaller. When in perfect condition the surface is almost completely concealed by meal. This is of one colour on the individual, but varies from a bright ochreous to dark brick-red or a muddy-brown (the latter probably discoloured). On removing the meal the elytra are seen to be clothed with small scales, and the raised interstices to have numerous granules; the larger punctures are also ringed with granules. From most of the large species it is distinct by the prominent humeral tubercle, which is often subacute, although less acute than in *O. marginalis* (a much smaller species). *O. pruinosa*, in which the shoulders are somewhat similar, is without a distinct tubercle between each shoulder and the suture. Three specimens of *O. aulica*, in the Blackburn collection, were placed as *O. excavata*, but the latter

species, as identified in my collection, differs in the rostrum, pronotum, and particularly in the elytra.

The type of *O. interrupta*, in the South Australian Museum, in 1926 was so greasy and dirty that it was necessary to wash it with chloroform; on this being done it became evident that it was a small specimen of *aulica*.

OXYOPS GEMELLA, Pasc.

In general appearance many specimens of this species approach those of *O. crassirostris*, and the appearance of both is considerably altered by immersion in alcohol, partial abrasion, etc.; but they may be readily distinguished, *inter se*, by the rostrum, that of *gemella* being parallel-sided, or slightly narrowed to the apex, and that of *crassirostris* being shorter and slightly dilated in front; specimens of the latter species often have, when in perfect condition, a long ridge of white setae on the third interstice, crowning the apical slope, and a shorter one on the fifth (the two sometimes connected), as they are depressed they can hardly be regarded as fascicles. In *gemella* there is usually an irregular patch of scales crowning the apical slope, but it is more oblique, and composed of shorter scales. Two specimens doubtfully identified by Blackburn (3) as *O. florea* belong to *gemella*.

OXYOPS BILUNARIS, Pasc.

Two specimens in the National Museum, from Victoria, are densely covered with a pale ochreous or chalky meal, concealing most of the clothing or derm, but leaving two large round blackish spots on the elytra, behind which the semilunar white marks, typical of the species, may be traced. From other specimens the meal is entirely absent, the round patches are deep black and very conspicuous, and the semilunar marks are of a snowy whiteness. Even on badly abraded specimens the round spots can be traced, and the semilunar white marks are seldom completely absent.

OXYOPS MARGINALIS, Pasc.

O. armata, Blackb.

Dr. Marshall, from comparison of the types, confirmed my conjecture that these names are synonymous.

OXYOPS TURBIDA, Pasc. (*Gonipterus*).

Medicasta obscura, Blackb.

O. minuscula, Lea.

O. uniformis, Lea.

This species is one of the most widely distributed of the genus; specimens before me are from South Australia (Ardrossan, Murray Bridge, Tanunda, Blanchetown, Lyndoch, Ooldea,

Oodnadatta, Hergott); Victoria (Sea Lake, Grampians), New South Wales (Mulwala, Tamworth); North Western Australia (Fortescue River and Murchison). The average size is about 6 mm., but it varies from 5 to 7. Fresh specimens are more or less covered with a rusty coloured meal, that partially conceals the clothing and derm; on many such specimens, however, a vague dark cross may be seen on the elytra. On removing the meal the scales are seen to be white, and to form three vittae on the pronotum and irregular fasciae on the elytra; a vague white cross on the elytra may often be noted. On the elytra the third and fifth interstices are but slightly elevated, more noticeably so at the summit of the apical slope, where the third often has a subfasciculate appearance. Specimens differ greatly in appearance with the partial removal of the meal and scales. *O. minuscula* has already been noted as a synonym, and *O. uniformis* has now to be added.

The above note was prepared recording *O. minuscula* and *O. uniformis* as synonyms of *obscura*. Dr. Marshall now informs me that they are synonyms of *Gonipterus turbidus*, which is an *Oxyops*.

OXYOPS SPARSUTA, Pasc.

Black, squamose and mealy.

Rostrum distinctly transverse, in front with rather small naked punctures, becoming larger and partly concealed elsewhere, with a short flat median carina, beginning immediately in front of an interocular groove. Antennae moderately thin, no joint of funicle distinctly transverse. Prothorax moderately transverse, sides rounded, base distinctly wider than apex; with large punctures, margined with granules, and with a short median carina. Elytra much wider than prothorax, shoulders somewhat thickened, beyond these parallel-sided to apical third, with rows of large, oblong, jagged punctures, becoming smaller posteriorly; interstices densely granulate, Mesosternal process well produced. Tibiae multidenticulate. Length, 7.5-9 mm.

Western Australia: Cunderdin, in September and October, Kellerberrin, Kalgoorlie, Mullewa and Ankertell.

Very distinct from all other species before me. The body parts appear to be always deep black, but the joints of the funicle are sometimes obscurely diluted with red. The meal varies from a muddy-yellow to yellowish-brown, and when dense, greasy or caked, fills many of the punctures and obscures the scales. The latter are really snowy-white; on the upper surface they are all pressed close to the derm, and are mostly rather wide; on the under parts they are mostly thinner. On the pronotum they form five feebly defined lines; on each elytron they appear as wide margining lines of black spots; four close to the suture, and four towards the side, the largest one is post-median, and is sometimes connected with one on the side; occasionally there are ten spots on each elytron. On specimens in

OXYOPS PICTIPENNIS, Blackb.

O. serricollis, Lea.

Two specimens, from Victoria and Kangaroo Island, appeared to agree with the description of *O. pictipennis*; they are bright red, with jet-black markings on the prothorax and elytra. They were seen subsequent to my description of *O. serricollis*, but considering that they were really immature specimens of that species, I asked for specimens to be compared with the type, and in reply Dr. Marshall wrote: "The darker specimen of *O. serricollis* from Kangaroo Island agrees well with the type of *pictipennis*, except that the latter is smaller and the setae on the elytra are slightly narrower. *O. irrasa* Pasc. (a female) is closely allied but distinct; Pascoe had actually associated with the type a black specimen of *pictipennis*. In *irrasa* the antennae are black, proportionately shorter and stouter, joint 2 of the funicle being shorter than 3+4 (equal to 3+4 in *pictipennis*); the frontal fovea is much larger and deeper, and the vertex is clothed with broad flat scales; the punctures and granules on the prothorax are somewhat fewer and larger; the elytra are broader and more quadrate, with the sculpturing very similar, but there are several dense tufts of long, ribbon-like erect scales; the bare impunctate patch in the middle of the venter is much larger, occupying one-third of the width on ventrites 3 and 4, and extending forwards to the middle of ventrite 2; the clothing of the lower surface consists of large broad flat scales, alternating with stout suberect setae." Fresh specimens are moderately covered with a brick-coloured meal. The derm on mature specimens is usually deep black, but on many is of a more or less dingy brown; in many the elytra appear to be black, irregularly mottled with red, or red mottled with black. On washing with chloroform all the scales are seen to be white. Several specimens have some loose fascicles of long setae on the elytra.

OXYOPS SICCA, Blackb.

A co-type of this species, in the National Museum, is fairly close in appearance to some specimens of *O. fasciata*, but the post-median fascia instead of extending forwards from the suture, is extended backwards from it; each elytron, as viewed from the side, appears to have two black spots, due to absence of clothing, one at the middle (filled with large punctures; from above this appears as an obtuse-angled triangle, forming, with its mate on the other elytron, an arrow-head), the other on the apical slope. A partly abraded specimen, without locality label, also in the National Museum, possibly belongs to the species, but the third interstice is strongly elevated at the base, again at the summit of the apical slope and moderately between, the fifth and seventh are somewhat elevated from beyond the middle to near the apex. On the co-type the third is only moderately elevated in parts, and the fifth and seventh are scarcely elevated above the adjoining ones.

good condition, but which have been soaked in chloroform, the spots are quite sharply defined, they vary somewhat in extent but not in disposition; even on old and greasy examples they are usually sufficiently distinct. On clean ones the granules are very distinct, especially on the bald parts. The body parts appear to be always deep black, but the joints of the funicle are sometimes obscurely diluted with red.

The above description was drawn up under the impression that the species was a new one, with a very short rostrum as in *O. sparsuta*, but differing from it in not having the scales of the upper surface "very slender bristle-like." Some specimens that were sent for comparison Dr. Marshall labelled "*Oxyops sparsuta* Pasc. var," and wrote of them, "Agrees with *O. sparsuta* Pasc., except that in your insect the scales are more elongate and less regularly elliptical, and the pattern is more sharply defined." Commenting on the species in a list, Mr. Arrow wrote, "Extremely like *O. florea* Pasc., but with roundish scales."

OXYOPS SEPULCHRALIS, Pasc. (*Gonipterus*).

The original description of this species is insufficient for its certain identification, and implies ("squamus griseis rarissime dispersis") that the type was badly abraded. Dr. Marshall writes that, "The type is a much abraded and dirty specimen. The posthumeral tubercle is absent, but there is a small conical projection on the mesosternal process, so that it should be transferred to *Oxyops*. In general form it looks like a small specimen of *O. crassirostris* Pasc., but the rostrum is longer than broad, the pronotum is not flattened, and sculpturing of the elytra less coarse, the basal tubercles being much reduced."

OXYOPS FLOREA, Pasc.

I wrote to Mr. Arrow, "Blackburn identified, with doubt as *florea*, the species you sent to me as *gemella*. I shall be glad if you will compare the types, particularly in the rostrum and third and fifth interstices of elytra, and let me know if you consider them synonyms." In reply, Dr. Marshall wrote, "*O. florea* and *O. gemella* are quite distinct."

"*O. florea*.—Longitudinal dorsal outline of rostrum strongly convex; eyes nearly flat; joint 3 of funicle nearly as long as 4; scales above and below comparatively long and narrow, most of them more or less raised, and some even suberect; the dorsal surface more rugose and with conspicuous shining granules."

"*O. gemella*.—Dorsal outline of rostrum flat; eyes strongly convex; joint 3 of funicle much shorter than 4; scales above and below much shorter and broader, all closely recumbent; the dorsal surface less rugose, the granules much flattened and nearly obliterated. A distinctly smaller insect."

OXYOPS SOROR, Lea.

Fresh specimens of this species are densely covered with a pale ochreous (almost stramineous) meal, in parts completely concealing the scales and derm; on being washed with chloroform the surface is seen to be almost evenly clothed with snowy-white scales, somewhat smaller on the elytra than on the pronotum.

OXYOPS MODESTA, Lea.

Victorian specimens of this mountain species, in the National Museum, vary in length from 7 to 10 mm.

OXYOPS DECIPIENS, Lea.

Some specimens of this species, from Brisbane, are in better condition than the types; two of them are rather densely covered with a sooty-brown meal; a third has evidently been in alcohol, and is without meal, its clothing is almost snowy-white; its elytra have very large punctures in about ten rows, three or four deep, from about the basal third to beyond the middle, then there is a zigzag fascia with a lichenous appearance, beyond which part of the surface is again covered with large punctures.

OXYOPS PARVICOLLIS, Lea.

Numerous specimens, recently taken on Thursday Island (the original locality), are rather densely covered with a snuff-coloured meal; to the naked eye each elytron appears to have two large, rusty-brown or blackish, transverse spots, one on the shoulder, the other just before the middle, the first extending to near the suture, the second to near the side. On removing the meal with chloroform the derm is seen to be intensely black, irregularly clothed with snowy-white scales. These are absent from a space on each elytron, resembling a C (commencing on the shoulder) on the right, or, on some specimens almost like an irregular O; behind it there is a conspicuous curved fascia of white scales (wider and less regular than on *O. bilunaris*, from which it also differs in many other respects). After washing, the prothorax appears to have four oblique black lines, due to granules showing through the scales, in addition to the median carina.

OXYOPS SCOPARIA, Lea.

The derm of this species is usually of a dark reddish-brown, but it and the scales and fascicles are often partly obscured by a snuff-coloured meal. Some South Australian specimens, that were in alcohol for some months, are completely free from meal, two of them are of normal colour, but the other is much paler (almost castaneo-flavous); their punctures are all deep and sharply defined, and are close together, although nowhere confluent. Five specimens, from Western Australia, are much darker (two of them have the derm of the prothorax and elytra

entirely deep black, and two are black except that most of the pronotum and the sutural region are reddish), and the fascicles crowning the tubercles are decidedly shorter (the five are alike in this respect, so it is evidently not due to abrasion). Specimens from which the scales and fascicles are abraded, are, in general appearance, close to those of *O. fasciculata* similarly abraded, but may be readily distinguished by the decidedly larger and sparser granules surrounding the elytral punctures.

OXYOPS VACILLANS, Lea.

On fourteen fresh specimens of this species, from Western and South Australia and Victoria, the intercoxal process of the mesosternum is produced as on many species of *Oxyops*, but on ten of them the latero-posthumeral tubercle is quite that of a normal *Gonipterus*, so that quite justifiably it might be referred to either genus. The whitish sutural vitta has numerous short projections on each side, and as the suture itself is usually blackish, it has a quite characteristic appearance.

OXYOPS AREOLICOLLIS, n. sp.

Dark reddish-brown. Densely clothed, multifasciculate and mealy.

Rostrum slightly longer than its subapical width, with a median depression obscured by clothing. Antennae rather short, fourth to seventh joints of funicle transverse, club short, its greatest width not twice that of the preceding joint. Prothorax about as long as wide, sides strongly rounded, granulate and strongly punctate. Elytra much wider than prothorax; with closely set rows of large punctures, each surrounded by small granules; fascicles supported on multigranulate elevations, especially those on the third interstice. Mesosternal process moderately produced and obtusely pointed. Tibiae with numerous small, but almost concealed teeth. Length (excluding rostrum), 7-8 mm.

Western Australia: Ankertell (H. W. Brown); Queensland: Cunnamulla (H. Hardcastle).

A rough strongly fasciculate species, allied to *O. fasciculata* and *O. scoparia*, but readily distinguished from both by the considerably wider funicle, which at first glance appears to be continuous with the club, although not as in *Bryachus squamicollis*. Fresh specimens are covered with an ochreous or brickdust-like meal, which causes the clothing to appear somewhat similarly coloured; but after washing with chloroform the clothing is seen to be almost snowy-white; on the under surface and legs it consists of stout setae or thin scales. On the pronotum there are three conspicuous lines of white clothing (the median one wider than the others), traversed by a line at the apex and another at the middle, so that the disc appears divided into four small squares, in addition a small square (partly visible from above) is marked off on each side of the base. The scutellum is densely

clothed. The elytral clothing is rather sparse, except for the fascicles; of these there are from twelve to about fifteen on each elytron, the largest of all crowns the apical slope on the third interstice, and the longest is near its base. The clothing, however, is easily disarranged. The prothorax before abrasion appears slightly transverse, and the clothing obscures most of the punctures and granules, the latter on the sides are rather large and pointed; on the elytra there are numerous granules on the suture, but they are normally concealed, the meal also obscures many of the granules ringing the punctures, the granules being nearer those of *O. scoparia* than of *O. fasciculata*.

OXYOPS MULTIARMATA, n. sp.

Dark reddish-brown. Squamose, fasciculate and mealy.

Rostrum slightly longer than the subapical width; punctures distinct in front, but partly concealed elsewhere. Antennae rather short, three apical joints of funicle transverse, and about half the width of club at its widest. Prothorax slightly longer than wide, sides strongly rounded; with large punctures and large subconical granules. Elytra much wider than prothorax; with rows of large punctures, ringed with small granules, in addition with numerous subconical tubercles; shoulders conspicuously armed. Mesosternal process moderately produced. Tibiae multidentate. Length, 7.5 mm.

Australia (J. Clark). Unique.

Readily distinguished from all the other fasciculate species by the numerous subacutely conical tubercles on the elytra, averaging about six on the odd interstices, from the third to the ninth. On *O. scoparia* there are many small pointed granules, all below the level of the tubercles supporting the fascicles; but on this species the tubercles are conspicuously above the support of the fascicles; these are also differently disposed and the shoulders are different. The fascicles, although conspicuous, have less elevated supports than those of the preceding species. The type being unique, was not washed with chloroform, but most of the meal (apparently of a muddy-yellow colour) has been removed and the clothing is seen to be white; on the under-surface and legs it consists of stout and fairly wide scales intermingled. From the prothorax the clothing appears to be partly abraded, but it was evidently dense in parts. On the elytra there are many small and several fairly large fascicles, of the latter four form a transverse series beyond the middle.

OXYOPS INSIGNIS, n. sp.

Black. Densely clothed with white scales and setae, mixed with a pale brownish meal.

Rostrum slightly longer than its apical width, with a shining median carina, most of its surface concealed by clothing. Prothorax moderately transverse, surface very uneven, and with a distinct median carina. Elytra much wider than prothorax; with

rows of large punctures; apex mucronate; each elytron with seven large tubercles, and with a conspicuous granulated ridge below the shoulder. Mesosternal process acute. Denticulations of tibiae concealed by clothing. Length, 14 mm.

Queensland: Townsville in August (F. P. Dodd). Type (unique) in British Museum.

The type being in almost perfect condition as regards its meal and clothing, was not washed with chloroform to enable the derm to be clearly seen, as the species is a very distinctive one by the seven large tubercles on each elytron; of these there are three on the third interstice, the largest of all subbasal, the second median, and the third crowning the apical slope; on the fifth interstice there are also three slightly posterior to those on the third, but in addition there is a fairly distinct but small one, half-way between the first and second; the other large tubercle is humeral.

OXYOPS TESSELLATA, n. sp.

Black, parts of antennae and of tarsi, obscurely diluted with red. Upper surface with small, round, glittering white scales, under surface with similar scales, mixed with thinner ones.

Rostrum strongly transverse; with comparatively small punctures, becoming larger near eyes. Antennae rather long and thin. Prothorax distinctly transverse, sides strongly rounded; with large punctures surrounded by distinct granules; median carina fairly long. Elytra much wider than prothorax; with rows of large, deep punctures, the interstices multigranulate; tips feebly mucronate. Mesosternal process well produced. Tibiae with close set but obscured denticulations. Length, 9 mm.

Western Australia: Kellerberrin, in January, on spearwood (J. Clark). Unique.

The rostrum is even shorter than on *O. sparsuta*, and its punctures are decidedly smaller. The scales on the elytra appear like small discs of mother-of-pearl, closely applied to the derm or inlaid. Many are quite circular; to the naked eye they cause the surface to appear speckled; on the pronotum they are usually less rounded, although mostly wide; and appear to form several feeble lines. A small amount of muddy-yellow meal was present on the type.

OXYOPS LEUCOPHOLA, n. sp.

Black, parts of antennae and of legs obscurely reddish. Clothed with white scales and setae.

Rostrum slightly longer than subapical width; with coarse, crowded, partially concealed punctures, except in front, where they are smaller and naked. Antennae moderately stout. Prothorax slightly shorter than the base, but distinctly longer than apex, sides rounded; with crowded granules and a short median line. Elytra much wider than prothorax, sides decreasing in width almost from base; with rows of large, deep punctures, almost evenly decreasing in size posteriorly; interstices narrow

and multigranulate, the odd ones slightly elevated; the third more noticeably near base than elsewhere (but not tuberculate), where the granules are unusually large and dense, shoulders thickened and with crowded granules. Mesosternal process acutely pointed. Tibiae multigranulate. Length, 9.5 mm.

New South Wales: Grenfell (Dr. E. W. Ferguson). Unique.

A speckled species due to numerous small clusters of snowy scales on the elytra. It is near *O. irrasa* and *O. pictipennis*, but the elytra are slightly more triangular in appearance, and are non-fasciculate (although the scales are not all placed singly), the pronotum has smaller granules and the rostrum is somewhat different. The type is without meal. The scales are white (on mealy specimens they would, no doubt, appear different); on the elytra they are of two kinds: stout and rather large ones, sloping at an angle of about 45°, and usually placed behind the punctures; and minute ones, closely applied to the derm; on the pronotum the scales are fairly large and form feeble lines; on the under parts the clothing consists of fairly stout setae interspersed with scales. The prothoracic granules are of several sizes intermingled, they appear to arise from an impunctate surface, or at least not to encircle punctures as on several other species.

OXYOPS CARINIROSTRIS, n. sp.

Black, antennae and tarsi obscurely reddish. With white clothing.

Rostrum slightly longer than wide; apex with dense and minute punctures rapidly becoming coarser, but still glabrous to about middle, thence to base still coarser, but partly concealed by clothing; with a median carina from interocular groove to middle, where it ends in a cross piece. Antennae moderately thin. Prothorax slightly shorter than the base, which is distinctly wider than apex, sides rather strongly rounded; densely punctate and granulate, and with a short median carina. Elytra much wider than prothorax; with rows of large, deep punctures, becoming smaller posteriorly; interstices rather narrow and multigranulate, the alternate ones feebly elevated in parts, the third more noticeably near base, but not tuberculate there; tips scarcely mucronate. Mesosternal process well produced. Tibiae conspicuously multidenticulate. Length 8.5-9.5 mm.

South Australia: Kangaroo Island (A. H. Elston and J. G. O. Tepper).

In general appearance the three specimens taken are like small rubbed ones of *O. reticulata*, slightly less parallel-sided than usual; but they differ from that species in having the elytral punctures smaller, more regular, and more evenly ringed with granules, and the rostral carina in the form of an elongated T. All the specimens have some dark brown (almost black) meal. The clothing on the under surface is not very dense, and consists of long, thin, white setae, becoming denser on the legs; on the pronotum simi-

lar setae are fairly dense along the middle, and form two inconspicuous lines on each side; the elytra are glabrous, except for a few setae at the base and sides.

OXYOPS SEMICIRCULARIS, n. sp.

Dark brown, some parts paler. Densely clothed with white scales, and heavily covered with pale meal.

Rostrum slightly longer than wide; apical half naked, and with dense punctures, basal half with coarser, partly concealed punctures, and with a thin median carina starting from the interocular groove. Antennae moderately long, no joint of funicle transverse, club rather long. Prothorax slightly transverse, sides rounded and slightly wider at base than at apex; densely granulate-punctate. Elytra much wider than prothorax, subparallel-sided to beyond the middle; with regular rows of large punctures, becoming smaller posteriorly; interstices mostly wider than punctures, the third somewhat elevated near base, with numerous minute granules. Mesosternal process moderately produced. Tibiae short, with numerous partly concealed denticulations. Length, 5.5-6.5 mm.

New South Wales: Bogan River (J. Armstrong); South Australia (National Museum), Ardrossan (J. G. O. Tepper).

Specimens in good condition are so densely covered with scales and meal that the derm is concealed, and the punctures, even on the elytra, are often completely filled; on all such specimens, however, there is a conspicuous black semicircle at the base of the elytra, enclosing a subquadrate, whitish scutellar patch; there may also be noticed three vague lines on the pronotum, where the scales are more condensed, and a line of white scales on the apical half of the suture. On removing the meal with chloroform, the scales are seen to be white throughout, and the basal semicircle of the elytra (which then becomes ill-defined), is seen to be due to sparsity of clothing. On the pronotum the scales are dense, rather long and almost evenly clothe the surface, except that they are denser along the middle than elsewhere. On the elytra the scales are smaller than on the prothorax, and most of them project backwards from minute granules; on the suture and about the scutellum they are larger than elsewhere. Washed specimens, compared with washed ones of *O. obscura*, are seen to differ in having the clothing sparser (except on the suture), the antennae are longer and the club decidedly thinner; unwashed specimens are at once distinctive by the black semicircle.

OXYOPS MICROLEPIS, n. sp.

Dark reddish-brown, antennae and tarsi (the claws black) paler. Densely squamose and mealy.

Rostrum slightly longer than wide; with small naked punctures in front, coarse and dense elsewhere. Antennae rather short, several joints of funicle transverse; club unusually short, being not

much longer than its greatest width. Prothorax slightly transverse, base distinctly wider than apex; closely and evenly granulate-punctate. Elytra much wider than prothorax, feebly diminishing in width from shoulders to beyond the middle, tips scarcely mucronate; with rows of large deep punctures, becoming smaller posteriorly; interstices evenly convex, but the odd wider than the even ones, with numerous small granules; shoulders somewhat thickened and multigranulate. Mesosternal process moderately produced. Tibiae multidenticulate; basal joint of tarsi unusually short. Length, 5.5-6 mm.

South Australia: Oodnadatta; Northern Territory: MacDonnell Ranges (Blackburn's collection).

A small species, structurally close to *O. obscura*, but fifth interstice not elevated above the adjacent ones even near the base, and elytral scales uniformly disposed, except that they are denser about the scutellum than elsewhere. On washing with chloroform the elytra are seen to be nowhere subfasciate (as on *obscura*) or maculate. The elytral scales are individually much smaller and shorter than those of *obscura*, or the preceding species, being so short that (except a few near the suture) it would take several of them, placed end to end, to reach across the interstice on which they rest, whereas on those species most of the scales are at least as long as the interstices supporting them; are wide; this is very conspicuous on washed specimens; on other part of the body the scales and setae are not so short. The scales are dense on most parts (less on the elytra than elsewhere), but they are so obscured by grease and meal on the only unwashed specimen in the collection, that on the pronotum no compacted lines are evident. The sutural interstice on each elytron is distinctly wider than the adjacent row of punctures, but many of these are wider than the adjacent interstices; their true sizes are normally concealed. The antennae are nearer those of *obscura* than the preceding species. *O. modica* has more prominent shoulders, less uniform elytral punctures and different clothing.

OXYOPS PARVOSABRA, n. sp.

Black, antennae and tarsi reddish. Moderately clothed with thin scales or setae, denser on under surface and legs than on upper surface; meal rather dense and snuff-coloured.

Rostrum with coarse, crowded and partly concealed punctures, except in front, where they are much smaller and naked. Prothorax slightly transverse, sides rounded and increasing in width to base; densely granulate-punctate. Elytra much wider than prothorax, subparallel-sided to beyond the middle; with rows of large, deep, rough punctures, becoming smaller posteriorly; interstices narrower than punctures except near apex, the alternate ones feebly elevated in parts, and all rather coarsely multigranulate. Mesosternal process moderately produced. Tibiae multidenticulate. Length, 6-7 mm.

South Australia: Ardrossan (J. G. O. Tepper).

A small species, slightly wider than *O. turbata*; comparing washed specimens together, those of the present species are seen to have larger elytral punctures with narrower interstices, the granules of which are larger, so that the general appearance is rougher; the basal joint of the front tarsi, although short, is distinctly longer than in *turbata*, the antennae are also longer, only the sixth joint of the funicle being feebly transverse. From *O. semicircularis*, *O. modica* and the preceding species, it is distinct by the much larger and rougher punctures and granules, and the narrower interstices. The scales and setae are really white, but the meal causes them to appear darker; on the pronotum a median line of clothing is fairly distinct, and one or two others on each side are sometimes traceable. On most parts of the elytra the setae are sparse and thin, but about the summit of the apical slope and near the middle the clothing is stouter than elsewhere, and forms feeble spots on the third and fifth interstices, it is also fairly dense about the scutellum. Each prothoracic granule contains a seta directed forwards or inwards, the containing punctures being quite distinct on washed and abraded specimens. The tarsi are usually, but not always, darker than the antennae.

OXYOPS PLATYDONTA, n. sp.

Dark reddish-brown. Moderately clothed with rather long, thin, white setae, becoming denser on the under surface and legs.

Rostrum slightly longer than wide; with fairly coarse punctures becoming small in front; with a rather short carina starting from a deep interocular groove. Antennae moderately long, sixth and seventh joints of funicle feebly transverse. Prothorax almost as long as wide, sides parallel except near apex; with a short median carina and with dense granules, each containing a setiferous puncture. Elytra much wider than prothorax, feebly diminishing in width from near shoulders, with rows of large, deep, suboblong punctures, becoming smaller posteriorly; interstices usually wider than punctures, with numerous granules, third slightly elevated above the adjacent ones, near base thickened, more elevated and multigranulate, junction of third, fourth and fifth marked by a preapical callus. Mesosternal process acutely produced. Legs longer than usual; tibiae thin, denticulations inconspicuous; claws very wide and flat, suddenly becoming pointed at the tips. Length, 8 mm.

Northern Territory (Blackburn's collection from Dr. Bovill).

Readily distinguished from all other known species by the claws. The clothing consists entirely of thin setae.

GONIPTERUS GIBBERUS, Boi.

There are before me nearly one hundred specimens of a species that is common in many parts of New South Wales, Victoria, and South Australia, and which vary in length, 7-10 mm., the

average size of Tasmanian specimens being about a millimetre longer than mainland ones, but the smallest before me is from Tasmania. They all, unless badly abraded, have a conspicuous triangle of white clothing on each side of the elytra, wide on the sides and narrowing to the suture, which they may or may not reach, close behind the scutellum. They all have the posthumeral tubercle conspicuous. Some of them were named in my collection for many years as *G. exaratus*, but probably in error, as Fahraeus in his lengthy description of that species does not mention a white fascia or triangles. They are probably *G. gibberus*, of which Boisduval in unusually lengthy descriptions says, "*laterally obsolete albido fasciatis*"; also "*une bande blanchâtre, oblique et laterale*"; and "*une bande blanchâtre, large qui, partant du côté remonte sur l'élytre un peu au-delà du milieu.*" Boisduval also describes the elytra as having the first four rows of punctures, counting from the suture, as more distinct than the others, but their distinctness is dependent upon the scales and meal; he gives the length as four (French) lines, and the locality as New Holland. Fresh Tasmanian specimens are covered with a pale ochreous or almost stramineous meal, but it is lost in alcohol, and is seldom in good condition on old specimens, especially greasy ones, on which it is usually confined to the punctures. On washing specimens with chloroform the whole of the clothing is seen to be white, with the triangles conspicuous on account of the density of their clothing. On complete abrasion the derm, where the triangles used to be, is seen to be paler than the adjacent parts, and to have smaller punctures. I cannot satisfy myself as to the limits of the species, specimens of which range towards *G. balteatus*, and *G. pulverulentus*, either of which may be a variety; in *balteatus*, however, the fascia on each side is narrower than usual, and fresh specimens of it certainly look very different from ones with wide triangles; on *pulverulentus* the white markings always terminate some distance from the suture, and are widest about the middle instead of on the sides, and on fresh specimens the meal is of a dark dingy red. Some specimens also vary towards the species here regarded as *scutellatus*, but on that one the posthumeral triangles are usually inconspicuous, and often not traceable.

GONIPTERUS NOTOGRAPHUS, Boi.

The original description of this species is quite useless. M. Lesne, from examination of the type, was able to supplement it with particulars (4), making it certain that it is a true *Gonipterus*, but even these are insufficient for its reasonable determination.

GONIPTERUS SUTURALIS, Gyll.

Typical specimens of this species, in good condition, may be readily recognised by a conspicuous line of white scales, or stout setae, continuous from between the eyes to the tips of the elytra,

but wider on the prothorax than elsewhere. It was named originally from New Holland; specimens now under observation are from New South Wales, Victoria and South Australia. Three specimens from Tasmania, identified by Blackburn as *G. scutellatus*, and two in Simson's collection similarly identified, agree perfectly in structure with normal specimens of *G. suturalis*, but the white line stops abruptly a short distance behind the scutellum. There are also many other specimens from Queensland, New South Wales, Victoria, and Flinders Island (Bass Straits), agreeing with the Tasmanian ones, or with the sutural vitta intermediate between them and typical *suturalis*. Many of them are covered with a rusty-red meal (probably all are normally so covered when young). I am satisfied that these specimens are not the *scutellatus* as identified by Dr. Marshall from South African specimens, but really represent *suturalis*, with the vitta not continuous.

GONIPTERUS LEPIDOTUS, Gyll.

The description of this species might very well have been founded upon specimens of *G. suturalis*, with the white vitta stopping abruptly behind the scutellum. In the description the expressions "*humeralis alte elevatis prominulis*" and "*callum humerale*" might be regarded as not applicable of *suturalis*, one of the few species of which typical specimens may be identified with certainty; yet of *suturalis* itself Gyllenhal says, "*humeralis alte elevatis prominulis*," and "*pone callum humerale*." The shoulders of *suturalis* are almost square, and three striae terminate at each of them; they are also densely granulate (as is most of the surface), so that they appear somewhat thickened, but when viewed either from the sides, or directly from above, they do not appear to be strongly elevated above the adjacent parts; although when viewed obliquely from behind they certainly appear tuberculate. The type was from New Holland. If the names are synonymous *G. lepidotus* has precedence, although specimens with the sutural vitta continuous to apex might well be considered as var. *suturalis*. Specimens that I refer to the species are from Queensland, New South Wales, Victoria, Tasmania and South Australia.

GONIPTERUS SCUTELLATUS, Gyll.

As instancing the difficulty that has occurred in connection with the correct name of a species of this genus that has unfortunately been introduced to South Africa, South America and New Zealand, reference may be made to an article appearing in *The Journal of the Department of Agriculture* at Pretoria, for November, 1924 (5), when not less than six specific and three generic names were considered in connection with it as follows:—

- Oxyops reticulata*, Boi. (formerly *Gonipterus*).
- O. cancellata*, Boh.
- Bryachus squamicollis*, Pasc.
- Gonipterus scutellatus*, Gyll.

G. exaratus, Fhs.

G. rufus, Blackb.

The species is a most difficult one to place from the original descriptions, but in the article Dr. Marshall is quoted as positively identifying it as *G. scutellatus*, from comparison with a co-type in the Oxford Museum. I do not think it wise to go beyond this identification, unless proved erroneous by examination of the type itself, although the description applies to several other species, quite as well as the one occurring in South Africa.

There are now before me twenty-five specimens, all taken on the same day at Rosebank, South Africa. They all have a wide median line of white setae on the pronotum, continued on to the scutellum, and for a short distance beyond it, a large and pale but vague triangle on each elytron, commencing behind the basal asperities, and continued on each side to slightly beyond the middle, the surface close to the triangle has somewhat sparser clothing than elsewhere, so that it is slightly accentuated; immediately beyond it, to the naked eye, there appears a feeble oblique dark stripe, but the triangles and dark stripes are often scarcely traceable even on nonabraded specimens; on some a feeble line of white clothing may be seen between the median one and each side of the pronotum. The base of each elytron (as seen obliquely from behind) appears to be conspicuously trituberculate, the tubercles covered with small black granules, the first on the third instertice, the second (and smallest) on the fifth, and the third on the shoulder, with the conspicuous posthumeral tubercle typical of the genus. These tubercles, however, are much as on most species of the genus. The size ranges 6-8 mm. Other specimens before me are from Queensland, New South Wales, Victoria and Tasmania; the type was from New Holland.

Of the other names mentioned:—

Oxyops reticulata was originally referred to *Gonipterus*, but is a true *Oxyops*.

O. cancellata has been recorded as a synonym of *reticulata*.

Bryachus squamicollis has distinctive antennae.

Gonipterus exaratus.—For years I had in my collection specimens identified as belonging to this species, but which now are regarded as probably belonging to *G. gibberus*. In the original description no mention is made of white elytral triangles, or a fascia, and the description might well have been drawn up from specimens here regarded as *G. lepidotus*. It was compared with *G. scutellatus*, but the differences mentioned would be quite consistent with the type being a partly abraded specimen of that species; if synonymous *scutellatus* has precedence.

G. rufus.—Small specimens with the triangles ill-defined are difficult to distinguish from specimens of *rufus*, that have been in alcohol and are without meal, but on such specimens of that species the elytral clothing is uniform, and there are never even vestiges of triangles.

Of other species with which it might be confused—

G. lepidotus.—The species here so regarded is consistently larger and is without a pale triangle on each elytron, but the clothing of the prothorax and scutellum is much the same.

G. gibberus.—The species here so regarded, when in good condition, has conspicuous triangles, but small and partly abraded specimens are often difficult to distinguish from *G. scutellatus*.

GONIPTERUS CINNAMOMEUS, Pasc.

A beautiful species, varying in appearance with the condition of the meal; when this is removed the clothing appears of a snowy whiteness, forming five lines on the pronotum, and the elytra are seen to have some nude black or blackish irregular spaces (including the elevations), about the base and on the apical slope, these, however, being well indicated on fresh specimens. It appears to be confined to Queensland.

GONIPTERUS BALTEATUS, Pasc.

Specimens of this species in good condition are covered with a rusty meal, through which a conspicuous vitta of white clothing shows on the scutellar region, shortly behind which it bifurcates to near the middle of the sides; the base of the elytra appears blackish, as also behind where the white stripes diverge, between each of these and the dark base, to the naked eye, the surface appears gradually paler. Specimens without meal are deep black, with white scales and a conspicuous oblique line of white on each side, often disconnected with the scutellum. The pronotum has fairly dense white scales, but not forming a distinct vitta.

GONIPTERUS FERRUGATUS, Pasc.

Fresh specimens of this species have a conspicuously rusty appearance. The four prothoracic vittae noted by Pascoe are due to the irregularity of granules and punctures, and disappear when the scales are exposed through the removal (in alcohol, etc.) of the rusty meal; there is also a feeble median carina. A co-type, from the British Museum, has the intercoxal process of the mesosternum distinctly produced and pointed, much as on many species of *Oxyops*, but the general appearance and the strong, subconical, posthumeral tubercle are those of a normal *Gonipterus*. Some specimens from Brisbane and the Blue Mountains agree well with the co-type.

GONIPTERUS LATERITIUS, Blackb. (formerly *Oxyops*).

The type of this species is in the South Australian Museum, and is certainly a small *Gonipterus*, having the conspicuous posthumeral tubercle typical of the genus. The intercoxal process of its mesosternum is feebly produced, but is not pointed (as it is in most species of *Oxyops*). Its rostrum is exceptionally short, being (near the apex) distinctly wider than long. It was very dirty,

but, on being washed with chloroform, proved to belong to a species taken by Mr. W. D. Dodd at Derby, and of which forty specimens were preserved in alcohol for several months, thus removing all the meal. These specimens are almost uniformly clothed with depressed white setae, forming a median line on the pronotum, dense on the scutellum, and moderately dense on the shoulders. To the naked eye the elytra appear to have six nude spots, due to the clothing there being sparser than elsewhere; two at the base, and four on the apical slope, the latter forming the corners of a square; occasionally there are four feeble spots at the base or none, sometimes the upper two of the four apical spots are very feeble, and occasionally the two outer ones are almost conjoined. Two specimens were not placed in alcohol by Mr. Dodd, and have their meal in almost perfect condition; it is dense, dark stramineous or yellowish, and completely conceals the punctures, and much of the clothing, several dark spots being indicated on the elytra; they were pinned, and were rather greasy twelve years after capture. A specimen that was sent and agreed with them was washed with chloroform, and proved to be identical with the type and the other specimens sent. It is about the size of *G. cinnamomeus*, and is structurally close to that species, except that the shoulders are less prominent, and that the tubercle on the third interstice near the base is less conspicuous; the clothing also is different. A specimen from the Swan River probably belongs to the species, but its setae are shorter (more nearly approaching scales) and denser on the elytra.

GONIPTERUS RUFUS, Blackb.

Fresh specimens of this species are densely covered with a rusty-red meal, becoming dark brown with age, or when greasy. The clothing is almost concealed, except that a white line is conspicuous from apex of prothorax to apex of scutellum. On complete abrasion the derm is seen to be red, or at most of a rather dark brown, so that such specimens, to the naked eye, almost resemble fresh ones. Those that have been in alcohol for some time, or that have been washed with chloroform, are seen to have white elytral clothing, moderately and evenly distributed, except that on the basal elevations it is sparser than elsewhere, and is nowhere condensed into spots; on the pronotum five rather feeble white lines may often be seen, but the sublateral ones are never sharply defined, and are often not traceable; on many even the median one is scarcely traceable. It is common in Tasmania and the mountain parts of Victoria and southern New South Wales.

Three specimens from Wyreema (Queensland) probably represent a variety of the species, but each posthumeral tubercle appears as a faint swelling only. On typical examples it is unusually prominent and conical, but it varies considerably on Tasmanian specimens, on some of which it is scarcely more prominent than on the Wyreema ones.

Four specimens from Launceston (Tasmania) probably represent another variety; they have the elytral clothing and punctures less uniform, the punctures being larger and many of them slightly encroaching upon the interstices, behind many of the punctures the setae are slightly condensed, causing a faint multimaculate appearance. The posthumeral tubercles are of normal prominence. The base of the head is black, as on most specimens of the species. They have not been in alcohol, and most of the meal is present on them. A specimen from the Victorian Alps evidently belongs to the same variety, but having been in alcohol the meal has been removed, and the multimaculate appearance of the elytra is more pronounced.

GONIPTERUS CRASSIPES, Lea.

Of two types of this species one is slightly, and the other badly abraded. There are now before me seven specimens in perfect condition as regards the clothing (but they are without meal). They have a conspicuous white triangle of clothing on each elytron, but the triangle is larger than on the species here regarded as *G. gibberus*, and its point is aimed at a considerable distance behind the scutellum (about the middle of the suture, instead of near the scutellum or even conjoined with it), the punctures about it are much larger than on that species (although on *gibberus* they are decidedly larger about the triangles than elsewhere), and the elevations are consistently black; the clothing of the pronotum is practically uniform throughout, certainly not condensed along the middle. A specimen from the Blackburn collection was identified with doubt as *G. exaratus*, but it is badly abraded, and the triangles are but little evident, much as on the type. One of the fresh specimens is from Mackay (Queensland), the others are without locality labels.

GONIPTERUS XANTHORRHOAE, Lea.

A male from Australia, in the Blackburn collection, and another from Queensland, in the National Museum, may belong to this species, but they differ from the type (a female) in having the derm black, except that parts of the elytra are obscurely diluted with red, and the clothing is somewhat different. On the type, behind many of the large elytral punctures, there is a small cluster, not a fascicle; of white scales, giving a speckled appearance to the surface that is absent from the others. The type, however, has the elytra in perfect condition and densely mealy, which is not the case with the others.

GONIPTERUS HUMERALIS, n. sp.

Dark reddish-brown, some parts almost or quite black. Moderately densely clothed with thin scales or setae, and covered with ochreous or snuff-coloured meal.

Rostrum about as long as wide. Prothorax about as long as the basal width, sides feebly diminishing in width from base to apical third, and then more strongly to apex; densely granulate-punctate. Elytra much wider than prothorax, tips obtusely mucronate, shoulders very prominent; with rows of large deep punctures, becoming smaller posteriorly; interstices multigranulate, the third with a conspicuous and moderately long tubercle near base, fifth with a small tubercle, between the one on third and shoulder; posthumeral tubercle very prominent. Mesosternal process not produced. Length, 7-8 mm.

New South Wales (National Museum and G. Masters); Queensland: Brisbane in January and February (Queensland Museum from H. Hacker).

The clothing consists of thin scales or setae, and is white (although normally obscured by meal) and rather dense on head and part of rostrum, along middle of pronotum, on scutellum, on a subquadrate space on basal fourth of elytra, and on under parts. Seen from the side each elytron appears to have an oblique dark line (due to the setae there being smaller and sparser than elsewhere) from the suture to near the apex; as a result most of the elytron appears to be occupied by a large pale triangle, separated by the dark line from a very narrow apical triangle, and with the elevated basal parts dark. The elevated parts of the elytra appear to be always darker than the adjacent surface, although on several specimens the entire derm of the body parts appears to be blackish. The shoulders, and the tubercles behind them, are unusually prominent, the width across the former being almost twice that of the base of the prothorax; although each shoulder is not itself tuberculate, when seen from behind it appears as an even larger and more prominent tubercle than the one on the third interstice, and much larger although less acute, than the posthumeral one. *G. gibberus*, *crassipes*, and *pulverulentus* have much less prominent shoulders, and much smaller and more conspicuous triangles on the elytra; *G. scutellatus* has also much less prominent shoulders, with the triangles smaller and less defined. *G. cinnamomeus* has prominent shoulders, but they slope back from the base at an angle of about 45° ; on the present species the base (except for the parts produced over the base of the prothorax) is almost straight; the clothing also is very different.

GONIPTERUS INCONSPICUUS, n. sp.

Black or dark brown, antennae and tarsi (claws excepted) reddish. Moderately densely clothed with stout setae, becoming denser on under surface and legs; and covered with rusty or snuff-coloured meal.

Rostrum and prothorax as described in preceding species. Elytra much wider than prothorax, tips mucronate, shoulders rounded; with rows of large deep punctures, becoming smaller posteriorly; interstices multigranulate; third with a rather

long obtuse tubercle, connected with base by a feeble ridge, fifth with a smaller tubercle between the one on third and shoulder; posthumeral tubercle large. Length, 7-8 mm.

Queensland: Gympie (Aug. Simson).

A rusty-looking, inconspicuous species, of which nineteen specimens were obtained, and which differ but little in size and appearance (allowing for post-mortem alterations in the meal and clothing). In general appearance they are much like *G. ferrugatus*, on a reduced scale, but on that species the intercoxal process of the mesosternum is distinctly produced (much as on *Oxyops*); on the present species it is decidedly shorter, and rounded in front. Structurally it is close to *G. scutellatus*, but the elytra are without the least traces of lateral triangles, and the median vitta of the pronotum is wider and less conspicuous. From the preceding species it differs in having elytra less narrowed posteriorly, shoulders rounded and less prominent, tubercle on third interstice near base smaller, and in the clothing. The clothing normally appears somewhat stramineous or pale brown (except on the under surface where it is mostly whitish), but on being washed with chloroform all the meal is removed, and it becomes white or almost so. On the pronotum it forms a wide median vitta and two narrow ones on each side, but the vittate arrangement is feeble and easily obscured; on the elytral interstices the clothing is almost uniform, but behind many of the punctures there are small clusters of scales (not fascicles) so that the surface appears feebly maculate.

Var. BIMACULATUS, n. var.

There are before me seven specimens that appear to belong to this species, and which have similarly speckled elytra; but, in addition, they have a distinct dark spot on each elytron, slightly beyond the middle, on the third and fourth interstices; each spot is due to sparsity of clothing, and partly to the clothing itself being black, the elevated parts at the base and the shoulders are also partly clothed in black, this being very noticeable on washed specimens.

Queensland (National Museum), Mackay (R. E. Turner), Bowen (Aug. Simson), Dalby (Mrs. F. H. Hobler); New South Wales: Tooloom in January (Queensland Museum from H. Hacker).

GONIPTERUS PARALLELICOLLIS, n. sp.

Black or blackish, antennae and parts of legs reddish. Setose, squamose and mealy.

Rostrum as long as its subapical width; with a feeble median carina, on each side of which is a shallow groove, bounded externally by an oblique ridge. Prothorax about as long as basal width, sides parallel to apical fourth, thence oblique to apex, with a short median carina; densely granulate-punctate. Elytra much wider than prothorax, tips very feebly mucronate, shoulders

rounded and thickened; with rows of large, deep punctures, becoming smaller posteriorly; interstices multigranulate, third with a large obtuse tubercle near base, fifth with a smaller one; post-humeral tubercle large. Length, 7.5-9 mm.

South Australia (National Museum), Kangaroo Island (Blackburn's collection and A. M. Lea), Mount Lofty Ranges (J. G. O. Tepper).

A fairly large rough, rusty-looking species, in appearance close to *G. ferrugatus*, but the intercoxal process of mesosternum normal. Structurally it is close to *G. geminatus*, but the metasternum is without longitudinal tubercles. A large suddenly elevated tubercle, near the base of the third interstice distinguishes from *G. xanthorrhoeae*; on that species the third interstice is moderately elevated there, but more as the highest part of a gentle elevation, which is continued almost to the middle. It is also structurally close to *G. crassipes*, but that species has a conspicuous pale triangle on each elytron, on specimens in good condition. The prothorax is longer in proportion than on *G. inconspicuus*, and the rostrum is different. The meal is present although not very dense on four specimens, but absent from the others; on the basal and apical thirds of elytra it is of a rather dark red, on the median third and all other parts it is ochreous. The clothing, (which is white when not obscured by meal) consists mostly of rather thin scales, on the elytra mixed with stouter ones, along the middle of the pronotum it becomes more setose in character. As on *inconspicuus* the elytra have a speckled appearance, owing to the compaction of scales behind many of the large punctures, the prothoracic clothing on some specimens seems to be in three- or five obscure vittae. On the pronotum there is a faint depression on each side of the median carina, and another towards each side; as a result there appear to be four feebly elevated spaces, along which the granules are more conspicuous than elsewhere; but this appearance is obscured on washed specimens.

GONIPTERUS CONICOLLIS, n. sp.

Blackish-brown, muzzle, antennae and legs paler. Moderately clothed with white scales and setae, becoming dense on the under parts.

Rostrum scarcely as long as the subapical width, apex red, shining and with small crowded punctures, with coarse, crowded, partially concealed ones elsewhere; with a basal furrow continued on to head. Prothorax about as long as the basal width, gently diminishing in width from base to apex, with a feeble median carina, densely granulate-punctate. Elytra as described in preceding species. Length, 9.9-5 mm.

Victoria: Fernshaw. Type in National Museum, co-type, I. 1919, in South Australian Museum.

Close to the preceding species, but rostrum without a median carina or oblique grooves, and its tip red; the prothorax is also

less parallel-sided, and the median carina is thinner and less defined; in these respects it is close to *G. xanthorrhoeae*, but the tubercles on the third and fifth interstices near base are more conspicuous. The derm of the pronotum is obscurely reddish in the middle, and this part is rather densely clothed with setae, towards the sides the clothing is sparser but stouter, and lineate in arrangement; on the elytra the clothing is fairly dense on the apical slope, elsewhere it has a spotted appearance owing to the compaction of a few scales behind the large punctures. The three specimens before me were evidently preserved in alcohol, as they are entirely without meal.

GONIPTERUS INTERMEDIUS, n. sp.

Blackish; muzzle, under surface, antennae and legs more or less reddish. Moderately clothed with white setae and scales, becoming denser on under surface and legs.

Rostrum slightly longer than wide; muzzle red, glabrous, and with dense and small punctures, elsewhere with crowded and coarser ones. Prothorax about as long as the basal width, almost evenly decreasing in width from base to apex; densely granulate-punctate. Elytra much wider than prothorax, tips feebly mucronate, shoulders somewhat rounded; with rows of large punctures, becoming smaller posteriorly; interstices near base and apex wider than punctures, in middle parts about as wide, third with an obtuse tubercle near base, connected with base itself by a slight ridge, fifth with a small one near base; posthumeral tubercle represented by an obtuse swelling. Mesosternal process not produced. Length, 7-8 mm.

New South Wales: Dorrigo (W. Heron), Brooklana (W. W. Froggatt); Queensland: Mount Tambourine, in December (H. Hacker, in Queensland Museum).

With the general appearance of *G. inconspicuus*, but with the conspicuous posthumeral tubercle of that species represented by a feeble swelling that disappears posteriorly (as on many species of *Oxyops*); one specimen from Dorrigo, however, has it slightly more prominent than on the others. *Oxyops vacillans*, which may be considered a *Gonipterus*, has the suture with white clothing throughout, and the mesosternal process more produced. *G. excavifrons*, with the posthumeral tubercle feeble, is larger, elytra more parallel-sided, rostrum more largely excavated, and with different clothing. The specimen from Mount Tambourine and one from Dorrigo, have most of the derm of a livid brownish-yellow, probably from immaturity, the former specimen has the appearance of a spiracle on each side of the subapical segment of the abdomen, but it is almost certainly accidental. The clothing along the middle of the prothorax consists of stout setae, but about the coxae it becomes true scales; on the elytra it is fairly even on the interstices, but it has a spotted appearance, owing to a few scales becoming compacted behind many of the large punctures.

tures; the preapical callosities, although feeble, are indicated by small white spots. The median carina of the pronotum is ill-defined. Two of the specimens are rather densely covered with a chocolate coloured meal, partly obscuring the derm and clothing.

IPTERGONUS ABERRANS, Lea.

A specimen from Three Springs (Western Australia) possibly belongs to this species, but differs from the type, and many other specimens, in having the median vitta occupying about one-third of the width of the pronotum (except close to the apex, where it is very narrow), instead of scarcely wider than the scutellum at the base; the medio-lateral patch on each elytron is larger, and the fascicles are larger; the third interstice is more elevated at the basal fifth, more conspicuously clothed with white scales, and at the apex of its elevated part is connected with the suture by a transverse patch of white scales.

PANTOREITES ARCTATUS, Pasc.

Fresh specimens of this species are covered with a brick-dust-like meal; owing to the irregularity of the disappearance of this material, or to its becoming greasy, many specimens look very different from others that have been in spirits. Some specimens from the Northern Flinders Ranges (S. Australia) have the white scales on the pronotum much denser than usual, so that the median vitta, although quite as large as on ordinary specimens, is less conspicuous.

PANTOREITES FUSIFORMIS, n. sp.

Black or blackish, antennae and tarsi obscurely reddish. Clothed with scales and setae, partly obscured by a yellowish or stramineous meal.

Rostrum evenly dilated from base to near apex, where the width is about two-thirds of the length; with crowded, partially concealed punctures, except about apex, where they are dense and small. Prothorax slightly longer than the basal width, almost evenly decreasing in width from base to apex; densely granulate-punctate. Elytra about one-fourth wider than prothorax, shoulders rounded, sides gently decreasing in width almost from base; with rows of large punctures, normally almost concealed; interstices wider than punctures, and densely and finely granulate. Length, 8-9 mm.

Western Australia: Cue (H. W. Brown).

About the average size of *P. major*, but that species has five conspicuous vittae on the elytra, all conjoined at apex, the intermediate ones commencing acutely near the shoulders; on the present species a semi-double one commences immediately behind a dark spot, due to naked punctures. Before washing mealy specimens the setae appear to be distinctly yellowish, but after wash-

ing with chloroform both setae and scales are seen to be snowy-white. The scales are dense on the head, scutellum, under surface and legs, form three conspicuous lines on the pronotum, on the elytra clothe the suture, fifth and sixth interstices from about the basal third, shoulders and sides; but on two unwashed specimens the upper surface appears clothed with white scales, except for a stramineous vitta on each side, extending from apex of prothorax to near apex of elytra. Although the elytra are distinctly wider than the prothorax, to the naked eye their outlines seem almost continuous with those of the latter. A specimen from Fortescue River (W. D. Dodd), appears to belong to this species; it was in spirits for some months, hence all the meal has disappeared; its upper surface has white clothing throughout, but the clothing being partly dense scales and thin setae, the parts clothed with the latter have a vittate appearance, the vittae placed as on the two unwashed Cue specimens; as on all the others, it has three naked punctures, about the middle at the basal third. A similar specimen is in the British Museum from Cos-sack.

Prophaesia.

Referred by Pascoe to the Hyperides, but stated to be "very near *Hypera* and *Pantoreites*." Of the latter he wrote, "I have no hesitation in referring it to the Gonipterinae." It appears to belong to the Gonipterides, and to differ from *Pantoreites* by the rostrum being longer. All the species known to me have the base of the prothorax bisinuate, with the concealed part densely padded, the mesosternum overlaps the hind coxae on each side (to about the same extent as in *Pantoreites*, but less than in other genera), the tibiae are strongly denticulate, and the specimens when fresh are all mealy; a combination of characters apparently confined to the Gonipterides.

PROPHAESIA ALBILATERA, Pasc.

Pantoreites longirostris, Lea.

At the time I named *P. longirostris* I was not aware that *Prophaesia* really belonged to the Gonipterides, and although the long rostrum certainly seemed out of place in *Pantoreites*, the other characters agreed so well that it appeared desirable to refer it to that genus. Dr. Marshall informed me that specimens of *longirostris*, sent for comparison, agreed with the type of *albilatera*.

PROPHAESIA ALBA, n. sp.

Reddish, claws black. Densely clothed with white scales, the elytra with some naked punctures.

Rostrum about as long as prothorax, almost straight, with a feeble concealed median carina, and with crowded concealed punctures, except about muzzle, where they are small. Antennae

rather thin. Prothorax about as long as the apical width, sides gently dilated to base; with crowded, concealed punctures. Elytra about one-third wider than prothorax, each side with a feeble posthumeral swelling; with rows of large punctures, mostly normally concealed. Length, 5.5-5 mm.

South Australia: Lucindale (B. A. Feuerheerdt).

Allied to *P. cretata*, but larger, prothoracic clothing thinner (approaching setae), elytra with scales only, and these more uniformly clothing the surface, so that (except on abraded specimens) only individual punctures appear naked, instead of large spots; on abrasion the punctures are seen to be large and in regular series, but they are mostly the width of or narrower than the interstices, and these are densely and minutely granulate. Seven specimens have the clothing in perfect condition, and on them the naked punctures are in irregular transverse series at the basal third, in the middle, and at the apical third, with a few near apex, but a slight amount of abrasion considerably alters their appearance; the entire pronotum is covered, but the clothing is denser along the middle than elsewhere. The seven specimens mentioned have the rostrum clothed almost to the tip, on two others with abraded elytra it is clothed only near base, but the difference may be sexual. They have probably all been in alcohol, but on one of them there is a slight amount of yellowish pubescence.

PROPHAESIA TENUIROSTRIS, n. sp.

Dull reddish, claws black. Densely clothed with white scales and with a yellowish meal; each elytron with two large, oblique, bald spots.

Rostrum long, thin, cylindrical and slightly curved; with a thin carina on basal half; with crowded punctures, towards the base partially concealed. Antennae thin, inserted in middle of sides of rostrum. Prothorax about as long as basal width, which is considerably wider than apex; punctures normally concealed. Elytra elongate-cordate, about one-third wider than prothorax; with rows of large, round, deep punctures, much wider than interstices, but, except on the naked spots, almost or quite concealed. Length, 5.5-5 mm.

Western Australia: Cue (H. W. Brown).

About the size of the preceding species, but rostrum decidedly longer, prothoracic scales stouter, elytra with larger punctures and narrower interstices, and each with two large bare spots. These are obliquely placed at the basal and apical thirds, and (except for the sutural clothing) form a feeble cross, which is traversed by an irregular white fascia. From *P. cretata*, to which it is closer, it differs in being larger, each elytron with but two large naked spots, and the apical slope densely and uniformly clothed; the elytral clothing consists of scales only (although these vary in size), not of scales and setae. Specimens are normally covered with a yellowish meal, but on washing with chloroform this is removed, and the scales are seen to be snowy-white.

Syarbis.

Specimens of this genus are often covered with a leaden-white kind of varnish, possibly due to some change in the meal; it is not due to old age, as the scales on such specimens are of normal density, even on some that have the upper surface completely covered by it.

SYARBIS NIGER, Roel.

S. plumbeus, Lea.

Specimens before me are all from New South Wales; one agrees perfectly in structure and clothing with normal specimens, but is entirely reddish. I am now satisfied that the type of *S. plumbeus* is a varnished one of *S. niger*; a second specimen agrees perfectly with it, and both have the clothing of *niger*; a third agreed with them (except that it is somewhat paler), and on being washed with chloroform the varnish disappeared, leaving the typical clothing of *niger*.

SYARBIS PORCATUS, Lea.

All the many specimens that I have seen of this species have five lines of scales on the pronotum. Three of it were standing in the Blackburn collection as *S. nubilus*, but of that species Roelofs says, "*Prothorace . . . vitta media lateribusque pallidis*," and again, "*Prothorax . . . formant trois lignes parallèles*."

SYARBIS NUBILUS, Roel.

S. brevicornis, Lea.

Occurs in many parts of South Australia. Many specimens have a more or less conspicuous leaden "varnish" in parts. One (evidently immature) is of a bright pale chestnut-brown, without a trace of meal or varnish, but with normal clothing. Another from Queensland (Charters Towers) probably belongs to the species, but has the oblique fascia of scales on each elytron approaching more closely to the suture than is usual. With an extended series of specimens of *S. brevicornis* it is evident that they belong to *S. nubilus*.

SYARBIS GOUDIEI, Lea.

A specimen of this species, from South Australia, was almost entirely covered with a leaden-white "varnish." On this being removed with chloroform the clothing was seen to be as on many others from South Australia and Victoria.

SYARBIS ALCYONE, Lea.

On specimens of this species, in good condition, the elytra have no compacted scales except those forming a conspicuous whitish line on the suture. It appears to be possible that it is the same as *S. subnitidus*, if the type of that species had the sutural scales

abraded; at least there are two specimens from the Blue Mountains that agree with the description of *subnitidus*, and appear to be *alcyone*, with the sutural scales abraded. A Victorian specimen without elytral scales, but evidently belonging to *alcyone*, was identified by Blackburn as "*?deyrollei*," but it can hardly be that species, which was described as of the shape of *S. niger* (a considerably narrower species).

SYARBIS SCIURUS, Pasc.

A specimen from Mount Squires (Elder Expedition) identified by Blackburn, without comment, probably belongs to this species, as it has an oblique postmedian spot on each elytron, but the base is hardly darker than the adjacent parts. Its pronotum is densely covered with whitish scales, and with fairly large punctures, each of which contains a large scale.

SYARBIS HAAGI, Roel.

Some specimens in the Macleay Museum, from North-Western Australia, were identified as *S. sciurus*. They have the base of the elytra conspicuously dark, and about one fourth of the apex (less at the suture and sides), but are without the postmedian spot noted as on that species. A specimen of the same species, from Onslow, in the National Museum, was identified as *S. sciurus* in the writing of Mr. C. French, Jr., but is in better condition, the dark base of the elytra being margined with strong scales; the dark apical part is partly covered with snowy scales, but a spot on each side of it is glabrous, margined with a ring of snowy scales. I believe these specimens represent a variety of *S. haagi*, the typical form of which has a much greater amount of both base and apex dark, leaving a conspicuous pale median fascia.

The ordinary length of Queensland specimens of *haagi* is about 5 mm. (as the type), but one from Magnetic Island is only 4 mm., and two from Charters Towers are 7 mm.

A specimen from Cape York, in the Queensland Museum, agrees so closely in structure with specimens of *haagi* that it does not appear to be distinct from that species. It is, however, of a rather pale castaneous, the elytra very slightly darker at base and apex than in the middle; its pronotum has three conspicuous lines of white scales, the median one of which is continued on to the scutellum.

SYARBIS POSTHUMERALIS, n. sp.

Castaneous, a large median blotch on each elytron paler. With small white scales forming five lines (two of them feeble) on pronotum, dense on scutellum, forming many small transverse or oblique lines on elytra, and fairly dense elsewhere.

Rostrum slightly longer than wide, with a rather shallow groove, beginning at a conspicuous interocular fovea, apically third depressed and with smaller punctures than elsewhere. An-

tennae short, six apical joints of funicle transverse. Prothorax about as long as the basal width, evenly decreasing in width from base to apex; with fairly numerous large and small, irregularly distributed punctures. Elytra much wider than prothorax, about twice as wide as long; with rows of large, round, deep punctures, much wider than interstices, even posteriorly; with a conspicuous posthumeral tubercle interrupting a row of large punctures. Legs short; tibiae with a few strong denticulations. Length, 4.5-5 mm.

Western Australia: Swan River (J. Clark and A. M. Lea).

The only species of the genus with a conspicuous posthumeral tubercle, as on most species of *Gonipterus*. *S. gonipteroideus* is without such a tubercle, but has a conspicuous one between each shoulder and the suture. The two specimens obtained differ somewhat in depth of colour, the blotch on each elytron of the smaller specimen being almost flavous; but otherwise they are in close agreement.

SYARBIS ALBIVITTIS, n. sp.

Reddish, clothed with white scales, on the upper surface lineate in arrangement.

Rostrum slightly longer than wide, with a shallow median groove beginning at a deep interocular fovea. Antennae short, six apical joints of funicle transverse. Prothorax about as long as the basal width, evenly decreasing in width from base to apex; with crowded punctures, many of large size. Elytra about twice the width of prothorax, shoulders slightly thickened, a feeble posthumeral swelling; with regular rows of large, round, deep punctures, wider than interstices; of these the third is somewhat elevated on the basal half. Legs short, tibiae with strong denticulations. Length, 4.4-5 mm.

Queensland, Brisbane (J. H. Boreham). Type in Queensland Museum; co-type I. 16121, in South Australian Museum.

On the pronotum the clothing is somewhat as on *S. porcatus*, but it is very different on the elytra. On the pronotum the white scales form three distinct and two feeble lines; on the elytra they clothe the suture throughout, the third interstice to the middle, the fifth from the middle to near apex, the fourth for a short distance connecting the markings on the third and fifth, and near the sides from the shoulders to the suture; there are minute scales on most of the other parts of the elytra, but they do not interrupt the vittate appearance to the naked eye.

The description was drawn up from three Brisbane specimens: two others from Herberton (C. J. Wild) differ in being slightly more robust; the markings appear to be the same, but are somewhat obscured by chocolate or muddy-brown meal, of which there is not a trace on the Brisbane specimens.

MINIA OPALESCENS, Pasc.

Referred with doubt by Pascoe to the *Gonipterides*; as its right to a position there seemed very doubtful, I asked for some infor-

mation as to the type, and Dr. Marshall replied: "Unfortunately there is only one specimen of the species. The genus does not present to me any very obvious affinities. In Lacordaire's system it runs down to his *Cleonides*, being excluded from the *Hyperides* by its connate claws. I am, however, of opinion that in spite of this latter character it had better be placed temporarily in the *Hyperides*."

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ART. XI.—*Descriptive Notes on Tertiary Mollusca from
Fyansford and other Australian Localities, Part I.*

By F. CHAPMAN, A.L.S., and F. A. SINGLETON, M.Sc.

(With Plates X., XI.)

[Read 9th December, 1926.]

The following notes deal in the main with species contained in the Tertiary molluscan fauna of the Orphanage Hill beds at Fyansford, near Geelong, now under revision by the present authors. A few species not occurring in that fauna, but of interest as allied forms, are also included.

Class PELECYPODA.

Family NUCULIDAE.

Genus *Nucula* Lamarck.

NUCULA OBLIQUA Lamarck.

Nucula obliqua Lamarck, 1819¹, p. 59. Hedley, 1902, p. 292.
Chapman and Gabriel, 1914, p. 301.

Nucula tumida T. Woods (*non* Phillips *nec* Hinds), 1877, p. 111.
Tate, 1886, p. 127, pl. vi., figs. 6*a*, *b*.

Nucula tenisoni Pritchard (*nom. mut.*), 1896, p. 128.

Observations.—In studying a long series of fossil shells from the various Tertiary horizons, we have reconsidered the question of their identity with the Recent *N. obliqua*, as affirmed by Pritchard, Hedley, and other authors. Upon comparison with Recent shells dredged by Mr. C. J. Gabriel in 8 fathoms off Point Cook, Port Phillip Bay, we observe that Lower Tertiary (Balcombian and Janjukian) shells tend to be somewhat produced anteriorly, and in some cases to be less inflated than is usual in the Recent shells. Upper Tertiary (Kalmnan and Werrikooian) examples commonly attain a rather larger size and are notably heavier in build.

After much consideration as to the relative stability of variations in the fossil forms, we cannot but consider that they all belong to one species, for the reason that although the general tendency in the fossils is towards a more elongate valve, a long series always contains some examples which are inseparable from the generally shorter and more convex Recent type, and conversely among living shells individual valves are more elongate than the average.

1.—Full references are cited in the list at the end of this paper.

NUCULA ATKINSONI (Johnston).

Portlandia Atkinsoni Johnston, 1880, p. 39.

Nucula Atkinsoni, Johnston: Tate, 1886, pp. 127, 128, pl. iv., figs. 3a-c. Johnston, 1888, pl. xxxi., figs. 16, 16a.

Observations.—In this species a great range of surface ornament is apparent, when a fair series is examined. The ordinary reticulated ornament, as a rule best developed towards the ventral region, often varies in the direction of suppression of the radial striae; the shell having in the extreme form, a corrugated rather than a reticose ornament. A feature hitherto unnoted is the presence in most cases of a discrepant ornament, in which a divarication of the concentric riblets is developed on the anterior side of the shell, but not, however, so well developed as in the genus *Acila*, H. and A. Adams.

The divarication varies in strength on the different geological horizons. Thus at Balcombe Bay and Muddy Creek (Balcombian) it is represented only by a slight corrugation on the extreme anterior border, whilst the valve-surfaces are nearly smooth. Most of the Janjikian variations are in the direction of a strongly corrugated shell, usually with pronounced divarication. Those from Beaumaris (Kalimnan) are smoother shells like the oldest representatives, and without divarication, but with a more trigonal shape.

This divaricate ornament is more constant in the New Zealand Tertiary species *N. sagittata*, Suter (1917, p. 65, pl. vii., fig. 6), a close relative of the Australian species. Compared with examples of Suter's species from Ardgowan, near Oamaru, our shells differ in their uniformly smaller dimensions, greater tumidity, less conspicuous resillifer and finer denticulation of the inner ventral margin, while in ornament the Australian species, though variable, always shows much deeper concentric ribbing but weaker radial striations.

NUCULA BREVITERGUM, sp. nov.

(Plate X., Figs. 1a,b.)

Description.—Holotype, left valve. Shell moderately thin, smooth, somewhat depressed, very inequilateral, subovate in outline. Umbo subacuminate; posterior margin short, straight, nearly at right angles to dorsal margin and meeting ventral border in a wide curve; anterior extremity sharply curved. Shell surface marked with fine concentric lines of growth of varying strength, more irregular in the ephebic stage. Interior of shell smooth, ventral margin flattened, without denticulations. Cardinal line having about 18 slightly uncinat teeth anteriorly and 6 oblique teeth posteriorly, separated by an acutely angular elongate resillifer. Lunule long, linear; escutcheon semilunate, bounded by a slight angulation with shell surface.

Length 8.75 mm.; height 6.5 mm.; thickness of valve 2 mm.

Observations.—The shortness of the posterior margin and the lengthened valve, with its generally depressed surface, separate this species from certain variants of fossil forms of *N. obliqua*. We have compared the present form with the Recent *N. superba*, Hedley (1902, p. 292; 1912, p. 131, pl. xl., figs. 1, 2), and although at first sight it appears to be comparable in outline, the latter species has a more strongly arcuate dorsal margin, whilst the shell surface is strongly concentrically ridged on the posterior region; moreover the inner margin of *N. superba* is finely denticulate, whereas in *N. brevitergum* it is smooth. The resilifer is deeper and wider in the recent than in the fossil species.

Occurrence.—Balcombian (Oligocene). Lower beds at Muddy Creek, Victoria (holotype in Dennant Coll., Nat. Museum).

Kalimnan (Lower Pliocene).—Jimmy's Point, Gippsland Lakes, Victoria. A solitary specimen occurs with *N. obliqua* from this locality in the Dennant Coll., but we feel some doubt as to its authenticity.

Family NUCULANIDAE.

Genus *Nuculana* Link.

NUCULANA CHAPMANI Finlay.

Leda apiculata Tate (non J. de C. Sowerby), 1886, p. 132, pl. ix., figs. 4a,b.

Nuculana chapmani Finlay (nom. mut.), 1924, p. 107.

Observations.—We are unable to include in the synonymy of the above species the Balcombian *N. acuticauda* (Pritchard), (1901, pp. 27, 28, pl. iii., figs. 4, 4a), as suggested by Dennant and Kitson (1903, p. 122, footnote). The latter species appears to be slightly variable in its degree of rostration, the type representing an extreme form (which can, however, be matched) in which the shell is posteriorly "drawn out into a very acutely pointed end" (Pritchard, *loc. cit.*). Of the other differential characters cited by Pritchard, the most ready means of distinction lies in the absence of the regular raised concentric ornament typical of *N. chapmani*.¹

1.—While this paper was passing through the press we have seen a statement by Mr. H. J. Finlay (*Trans. N.Z. Inst.*, lvii., p. 523, 1927) that "*N. chapmani* does not occur at Balcombe Bay (nor probably in the Balcombian at all), being represented by *N. acuticauda* Pritch., and a variety of it." We have examined examples in the Dennant Coll. (Nat. Mus.) of *N. chapmani* Finlay [= *Leda apiculata* Tate] from the lower beds at Aldinga Bay, the type locality subsequently selected by Finlay, which agree well with Tate's description and figure. The two Mornington examples labelled as *N. apiculata* in the Dennant Coll. we identify as *N. acuticauda* (Pritchard), but of a series of 177 *Nuculanae* collected at Balcombe Bay by Mr. F. A. Cudmore, the great majority agree closely with the Aldingan topotypes of *chapmani*, the 28 exceptions being referable to *acuticauda*. The horizon of Finlay's type locality (Lower Aldingan) is, by the way, generally correlated with the Janjukian, and is certainly not Eocene.

Genus *Sarepta* A. Adams.*SAREPTA OBOLELLA* (Tate).

(Plate X., Figs. 2-7).

Leda obolella Tate, 1886, p. 130, pl. v., figs. 3a,b.*Sarepta? tellinaeformis* Hedley, 1901, pp. 26, 27, fig. 8.*Sarepta obolella*, Tate sp.: Hedley, 1902, p. 295.*Ovaleda tellinaeformis* Hedley: Iredale, 1925, p. 250.

Observations.—Iredale (1925, p. 250) has proposed the new generic name *Ovaleda*, citing as genotype Hedley's *Sarepta? tellinaeformis*, which the latter author finally regarded as conspecific with the fossil shell. Iredale states that "the recent forms are generally higher, deeper, with coarser sculpture, the beaks a little more angulate, and the hinge teeth-fewer." At the same time he admits the relationship to be "very close and of disputable value," and proposes to indicate this by the use for the recent shell of the trinomial *Ovaleda [obolella] tellinaeformis* Hedley.

We have had on loan from the Australian Museum four virtual topotypes of Hedley's species, one of which we figure (Pl. X., Fig. 5), from 33-56 fathoms, Botany Heads, as well as a series of eight, illustrating growth stages, from off Cape Three Points, both in New South Wales. Fossil material in the National Museum used for comparison included a fine series of topotypes of Tate's species from the lower beds at Muddy Creek (Dennant Coll.), as well as many examples from Fyansford (G.S.V. Coll.).

At first sight the recent and the fossil specimens appear to show some differences that might be of specific value, such as in outline and inflation, but these features can be exactly matched, as illustrated on Pl. X., Figs. 6, 7, in a long series of the fossils, and these again pass insensibly into the commoner, more elongate form, which is illustrated by Figs. 2-4. We find the sculpture variable in both, while the hinge teeth appear to us to be equally numerous, but more salient in the fossil shells, a feature evidently due to loss of area resultant on dissolution of the inner conchiolitic margin. We are thus unable to find any specific break, nor can we see reason for the removal of the species from *Sarepta*.

SAREPTA PLANIUSCULA (Tate).

(Plate X., Figs. 8-12.)

Leda planiuscula Tate, 1886, p. 131, pl. v., fig. 2.

Note on Tate's Syntypes.—The tablet bears five specimens from the Adelaide bore, of which all but the two smallest are imperfect. Tate has labelled as types the whole series, and from the dimensions given has evidently figured the largest example, which we here designate as lectotype (Pl. X., Fig. 8). This, the uppermost shell on the tablet, is $5\frac{1}{4}$ mm. long, $4\frac{1}{4}$ mm. high, and 1 mm. in thickness, which agrees fairly well with Tate's $5 \times 4\frac{1}{2}$ mm. and his figure, drawn by Chidley, measuring 5×4 mm.

Observations.—Tate (*loc. cit.*) states: "Shell minute, similar to *L. obolella*: comparing equal-sized specimens of each, *L. planiuscula* is more deepened and the outline approaches more to the circular."

In addition, we note that *S. planiuscula* possesses a less prominent umbo and, if the lectotype be an adult shell, is a much smaller species than *S. obolella*. Nevertheless, owing to the paucity and unsatisfactory nature of the available material, we are unable to feel entirely satisfied as to its specific validity.

Family PECTINIDAE.

Genus *Propeamusium* Gregorio.

PROPEAMUSIUM ATKINSONI (Johnston).

(Plate X., Figs. 13-19.)

Amusium Atkinsoni Johnston, 1880, p. 41. Idem, 1888, pl. xxxii., figs. 15, 15a.

Pecten Zitteli, Hutton: Tate, 1886, pp. 115, 116, pl. vii., figs. 3a-c (non Hutton).

Amusium atkinsoni Johnston: Marwick, 1924, p. 318.

Observations.—Marwick (*loc. supra cit.*) has recently discussed the supposed identity of the Australian shell with the New Zealand *Pecten zitteli* Hutton, as affirmed by Tate. We accept Marwick's conclusion that "specific identity is not established, and until better New Zealand material is available the Australian species should be called *Amusium atkinsoni* Johnston." We further agree with Marwick in referring our shell to *Propeamusium*, but consider Gregorio's name worthy of generic rank.

Johnston in his original description of a Table Cape shell appears to have regarded both valves as having a similar concentric ornament. Tate (*loc. cit.*) has commented upon this and given a full description of the discrepant ornament of the right valve, based apparently on Balcombian examples from Muddy Creek, from which locality we figure further specimens. The type of *Amusium atkinsoni* should be contained in the Johnston collection, now in the Tasmanian Museum, Hobart, but has not yet come to light.

The only topotype available to us is a right valve (Pl. X., Fig. 13) collected by Mr. F. A. Cudmore at Table Cape, Tasmania. This shell, though considerably obscured by matrix, shows the radial ribs and concentric ornament, which constitute a fenestrate pattern, to be of equal strength. The dorso-ventral diameter is relatively greater than in the Muddy Creek examples, which approach more to the orbicular in outline. The well-preserved right valves from this locality show in addition to a primary series of radial costae, continuous over the whole valve excepting on the embryo, a secondary series, much shorter and extending over the ventral region to about one-third to one-half of the valve.

Family CARDITIDAE.

Genus *Venericardia* Lamarck.*VENERICARDIA GRACILICOSTATA* (T. Woods).

(Plate XI., Figs. 20, 21.)

Cardita gracilicostata T. Woods, 1877, p. 112. Tate, 1886, p. 152, pl. ii., figs. 6, 8.

Note on Tate's Plesiotypes.—The tablet bears four valves from Table Cape (R. M. Johnston coll.), of which the two on the left are marked as figured. The upper of these agrees in dimensions with Tate's description and figure (*loc. cit.*, pl. ii., fig. 6), but the other measures $21\frac{1}{2}$ mm. long by $18\frac{1}{2}$ mm. high, whereas the illustration (Fig. 8) has been enlarged to 29×25 mm. Both are right valves, Chidley's drawings having been reversed in lithographing, and are here refigured.

Observations.—The number of ribs is given by Woods as 30 to 34; by Tate as about 30; and we find 31 in each of Tate's figured specimens and 32 in the other two on his tablet. The five largest topotypes in the Dennant Coll. (National Museum), exhibit 31, 35, 31, 31, 34, giving a mean for nine examples of 32 ribs.

V. gracilicostata attains much larger dimensions than *V. scabrata*, and is matched in size only by a *Venericardia* common in the Janjukian of Spring Creek, hitherto identified as *V. polynema* on Tate's authority, but herein described as a new species, *V. janjukensis*.

V. latissima is closely allied in number of ribs and in ornament, but is wider posteriorly and suborbicular rather than suboval in outline. The young forms of the above four species are almost impossible to separate.

VENERICARDIA LATISSIMA (Tate).

(Plate XI., Figs. 22, 23.)

Cardita latissima, Tate, 1886, p. 153, pl. ii. (not pl. x., as in text), fig. 5.

Note on Tate's Metatypes.—Of the eleven examples on the tablet, from the Adelaide-bore, none is marked as figured, but the left valve in the top left-hand corner agrees in dimensions with Tate's description and the accompanying reversed figure. It is here refigured and regarded as holotype. This specimen (the largest) is $31\frac{1}{2}$ mm. long and 29 mm. high, and bears 34 ribs, of which the three anterior are very small. Another, of nearly equal dimensions, has 30 ribs, and the next four smaller examples 32, 28, 28 and 28 respectively, giving an average of 30 ribs, the number given in Tate's description. The first of these smaller shells, measuring 21 mm. long and 19 mm. high, and bearing 32 ribs, we also figure. The juvenile series bear 27, 23, 21, and 14 ribs in a very minute shell.

Observations.—Tate compares this shell in ornament with juveniles of *V. gracilicostata*, but notes the difference in shape. This ornament of erect scales is, however, also characteristic of the other members of this group, *scabrosa*, *polynema* and *janjukien-sis*, as well as of other species. The outline to some extent recalls that of *V. polynema* (regarded in this paper as a variety of *V. scabrosa*), but this is more numerous ribbed and narrower anteriorly, as well as being a smaller shell in the adult stage.

VENERICARDIA SCABROSA (Tate).

(Plate XI., Figs. 24-26.)

Cardita scabrosa Tate, 1886, p. 152, pl. ii., fig. 4. Pritchard, 1896, pp. 132, 133.

Note on Tate's Metatypes.—Tate's original tablet bears fifteen examples, of which the top row of three is marked as from the Murray Cliffs, the locality given for his figure, but none is indicated as the type or as having been figured. The central specimen, here illustrated, would agree quite well with Tate's figure by Chidley, were it not that other illustrations on the same plate are known to have been reversed. It is, moreover, of smaller dimensions than those given by Tate ($18\frac{1}{2} \times 15$, as against 21×16 mm.). The tablet, however, is the only one of this species in the type collection of the Tate Museum, University of Adelaide, and we therefore designate the shell now figured (Pl. XI., Fig. 24), as lectotype of the species, while indicating the discrepancies above noted.

Counting the minute anterior ribs, we find in Tate's Murray River shells 32, 32 and 29, averaging 31 ribs; in his Muddy Creek series 31, 34, 29, 28 and 33, also averaging 31. Of these latter we have excluded the middle shell in the third row, here figured (Pl. XI., Fig. 29), as being better referable to *polynema*, with which it agrees in outline. It bears 34 ribs. Another of somewhat similar outline is the left-hand shell in the second row (Pl. XI., Fig. 25), having 31 ribs, and retained by us in *scabrosa* (*s.str.*). We are inclined to refer the juvenile Cheltenham [=Beaumaris] shell with 21 ribs, in the bottom row of the tablet, to *V. spinulosa* (Tate) rather than to *V. scabrosa*.

Tate's original diagnosis of the species well fits the lectotype, from which, indeed, it may have been drawn, and there is therefore no necessity to give any further description if the smaller dimensions (length $18\frac{1}{2}$ mm., height 15 mm., and thickness of valve $5\frac{1}{2}$ mm.) be borne in mind, as well as the fact that the lectotype is a right valve.

Observations.—The distinctive characters of the lectotype of *V. scabrosa* seem to be its long quadrate outline, its steeply sloping posterior margin, not very salient umbones, and squarely keeled costae, 32 in number. We indicate hereunder our belief that both in outline and in costation this species runs into *polynema*, which we reduce to varietal rank, and under which heading we discuss their differential characters.

VENERICARDIA SCABROSA, var. POLYNEMA Tate.

(Plate XI., Figs. 27-29).

Cardita polynema Tate, 1886, p. 153, pl. ii., fig. 7.

Note on Tate's Metatypes.—The tablet labelled *Cardita polynema* from the type collection in the Tate Museum, University of Adelaide, bears ten examples, all from Schnapper Point [=Balcombe Bay], the only locality cited in Tate's original description. While none is marked as figured, the left valve in the top left hand corner is the only one agreeing with the dimensions (18 x 15 mm.) and number of ribs (37) given by Tate, and is identified by us as the holotype (Pl. XI., Fig. 27). Chidley's figure is reversed and also enlarged, and does not satisfactorily represent the outline.

Of the remainder, shells comparable with the holotype bear 35, 32, 34 and 36 ribs, the last of which we also figure (Pl. XI., Fig. 28). Smaller examples have 33(?), 32, 32, and 30, and a juvenile 15 ribs respectively.

Observations.—Tate appears to have selected an extreme form for his diagnosis of *V. polynema*, and in a long series we have not seen another example so numerous costated as the holotype. We suggest that the definition of *V. polynema* be extended to include shells of 34 to 37 ribs having also a subovate outline, and that the 32-ribbed shell of Tate's series be referred to *V. scabrosa*, to whose more subquadrate outline it approximates.

The close relationship of the above species is emphasized by our belief that each of Tate's type tablets contains an example of the opposite species. These two names appear to us to have been applied to extreme members of a very variable form, in which the costation ranges between extreme limits of 28 to 37 ribs, and the outline from subquadrate to suboval, and since *scabrosa* has page priority we accord to *polynema* only varietal rank. If the shape be taken as a criterion, then *polynema* must be extended to include shells (e.g., Pl. XI., Fig. 25), with only 31 ribs, which can hardly be reconciled with Tate's diagnosis and name. It appears preferable to utilize the costation, referring shells with less than 34 ribs to *scabrosa*, s.str., and to var. *polynema*, the more numerous ribbed forms. These latter (Figs. 27-29) are typically suboval in outline, narrowed anteriorly, while the less numerous costate shells are usually subquadrate (Fig. 24), but occasionally approximate to the suboval (Fig. 25).

VENERICARDIA JANJUKIENSIS, sp. nov.

(Plate XI., Figs. 30a,b, 31.)

Cardita polynema auctorum, non Tate, 1886.

Description of Holotype.—Right valve, roundly subquadrate in outline, anterior beneath the beak not so produced as in *V. gracili-*

costata, so that the umbo is placed more anteriorly than in that species; lunule ovate, valve deep, giving a more tumid profile than in *V. gracilicostata*, in which the ventral region is more depressed. Costae 36, rather sharply V-shaped, with erect scales, developing into spines on the last four or five posterior ribs; interspaces wider than ribs and marked by distinct lines of growth, which are stronger when confluent with the scales of the ribs. Interior margin strongly denticulate, crenulations sharply pointed.

Observations.—This, the commonest species of the genus in the Spring Creek beds, has always been listed as *polynema*, and we figure (Pl. XI., Fig. 31), an example so identified in the Tate collection. It resembles Balcombian topotypes of *polynema* only in the number of ribs, but is a very much larger shell of heavier build, with the umbo placed less anteriorly than in typical *polynema*. The affinities of the Spring Creek shells, however, lie rather with *V. gracilicostata*, which is of similar heavy build and large dimensions. The former, as stated by Tate, are less produced anteriorly and usually more numerous ribbed. The holotype of *V. janjukiensis* bears 36 costae as against 31 in Tate's plesiotype of *V. gracilicostata*, while series of each average $34\frac{1}{2}$ and 32 respectively, with limits of 34-37 and 31-35 ribs, the costation in neither case being dependent purely on size. In the ephebic stage the Spring Creek shell has a characteristic humped appearance due to steepening of the umbono-ventral profile towards the latter margin, but this is lost again during geronticism. In *V. gracilicostata* the posterior region of the shell is more depressed and the denticulae of the internal margin are rounded and not pointed, as in the present species.

Although topotypes of these two species may readily be separated, there occur in the Dennant Coll., Nat. Mus., shells labelled C. Otway, Br. Ck. and Picnic B. (probably Brown's Creek, on the Aire Coast, and Picnic Point on the Aire River), bearing 34, 31 and 30 ribs respectively. While the three shells exhibit minor differences, yet they combine the general shape of the Spring Creek shell with a less degree of costation, and may be regarded as annectant forms between *V. gracilicostata*, the Table Cape representative, and *V. janjukiensis*, the Spring Creek equivalent. In the absence of a continuous series linking the two forms at the one locality, as obtained in the case of *scabrosa* and *polynema*, we prefer to keep *gracilicostata* and *janjukiensis* at present as distinct species.

Occurrence.—Janjukian (Miocene).—Common at Spring Creek (Bird Rock Cliffs), Torquay, Victoria. Holotype coll. and pres. to Nat. Mus., Melb., by F. A. Singleton.

Acknowledgments.

We are again under deep obligations to Sir Douglas Mawson and Mr. C. T. Madigan for the loan of types from the Tate Collection, in the Geological Department of the University of Adelaide.

To the Director of the Australian Museum (Dr. C. Anderson) and the Conchologist (Mr. T. Iredale) we are indebted for the loan of recent mollusca from New South Wales.

Mr. F. A. Cudmore has kindly lent and subsequently presented to the National Museum a specimen of *Propeamysium atkinsoni* from the type locality of Table Cape.

Our best thanks are also due to Mr. C. J. Gabriel for giving us on many occasions his valued aid in regard to recent allied species and for the loan of material from his collection.

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EXPLANATION OF PLATES.

(Numbers in brackets refer to registered specimens in the National Museum, Melbourne.)

PLATE X.

All figures 1·8 times natural size.

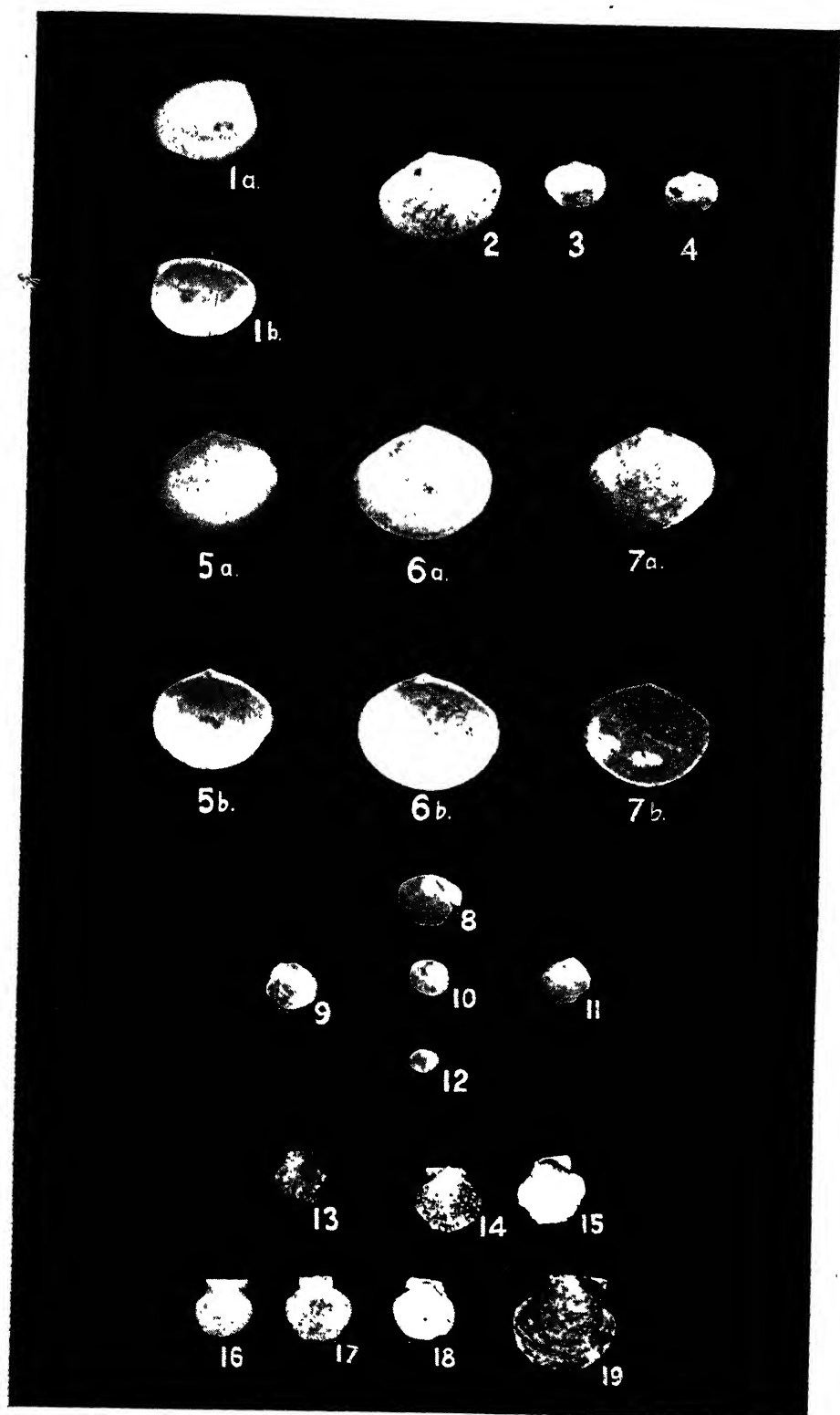
- Fig. 1.—*Nucula brevitergum*, sp. nov. Balcombian (Oligocene). Muddy Creek, lower beds, Vic. Holotype, left valve. Dennant Coll., Nat. Mus., Melb. (a) exterior; (b) interior. [13461]
- Figs. 2-4. *Sarepta obolella* (Tate). Balcombian. Muddy Creek, lower beds, Vic. Plesiotypes, adult left and juvenile right valves. Dennant Coll., Nat. Mus. [13462-4]
- Fig. 5.—*S. obolella* (Tate) (= *S. tellinaeformis* Hedley). Recent. Botany Heads (33-56 faths.), N.S.W. Plesiotype, right valve. Reg. No. 48115 in Aust. Mus., Sydney. (a) exterior; (b) interior.
- Fig. 6.—*S. obolella* (Tate). Balcombian. Muddy Creek, lower beds, Vic. Plesiotype, right valve. Dennant Coll., Nat. Mus. (a) exterior; (b) interior. [13465]
- Fig. 7.—*S. obolella* (Tate). Barwonian. Orphanage Hill, Fyansford, Vic. Plesiotype, right valve. G. S. V. Coll., Nat. Mus. (a) exterior; (b) interior. [13466]
- Figs. 8-12.—*S. planiuscula* (Tate). Janjukian (Miocene). Adelaide Bore, S.A. Syntypes. Tate Coll., Adelaide University.
- Fig. 13.—*Propeamusium atkinsoni* (Johnston). Janjukian. Table Cape, lower beds, Tas. Plesiotype, right valve, exterior. Nat. Mus. Coll., pres. F. A. Cudmore. [13467]

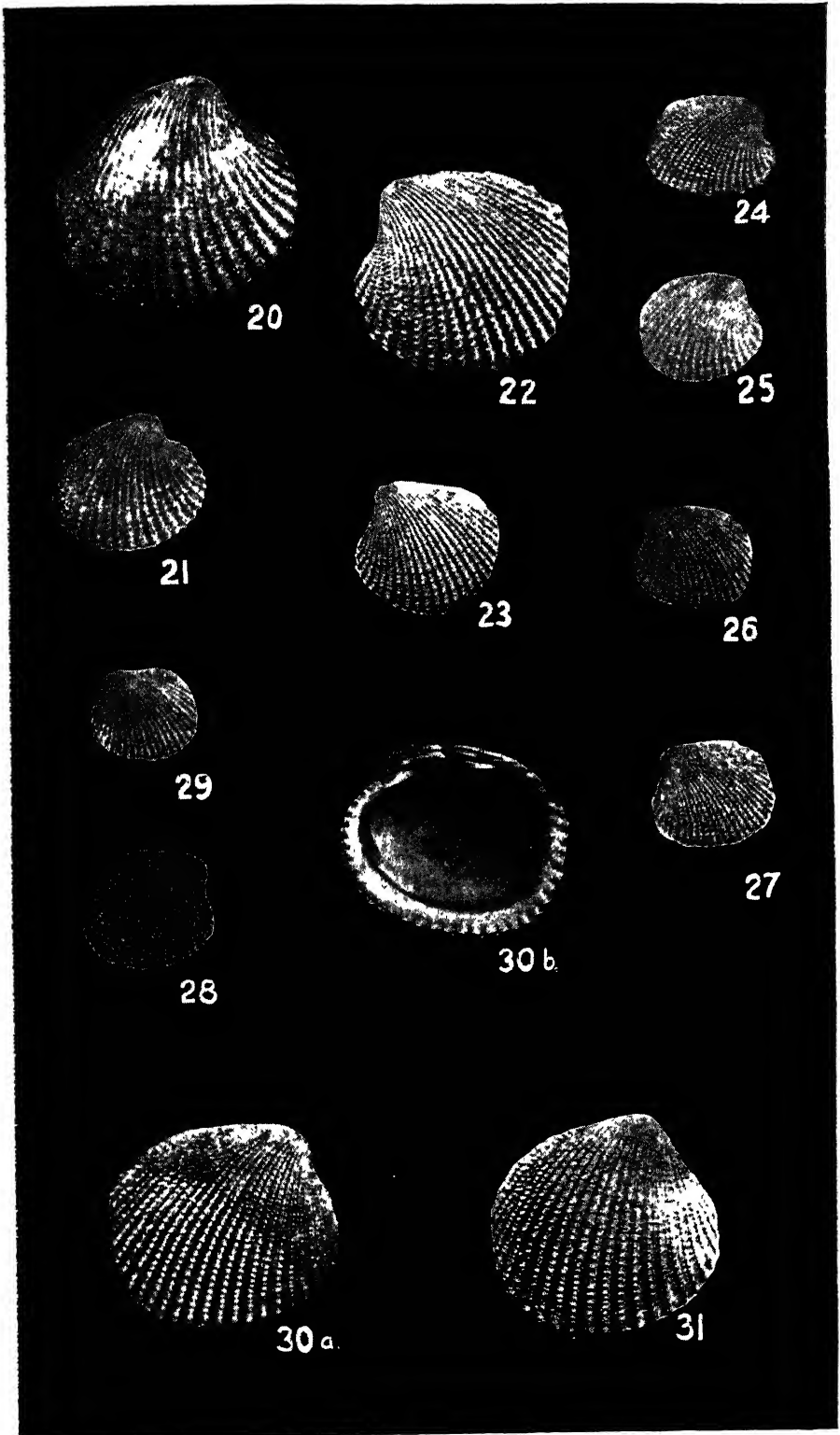
- Figs. 14-19.—*P. atkinsoni* (Johnston). Balcombian. Muddy Creek, lower beds, Vic. Plesiotypes. Fig. 14, right exterior [13468]; Fig. 15, right interior [13469]; Fig. 16, left exterior, [13470]; Fig. 17, right exterior [13471]; Fig. 18, left interior [13472]; Fig. 19, left exterior, unusually large specimen [13473]. Denning Coll., Nat. Mus.

PLATE XI.

All figures natural size.

- Figs. 20, 21.—*Venericardia gracilicostata* (T. Woods). Janjukian. Table Cape, Tas. Plesiotypes, right valves. Tate Coll. (coll. R. M. Johnston), Adel. Univ.
- Fig. 22.—*V. latissima* (Tate). Janjukian. Adelaide Bore, S.A. Holotype, left valve. Tate Coll., Adel. Univ.
- Fig. 23.—*V. latissima* (Tate). Adelaide Bore, S.A. Metatype, left valve. Tate Coll., Adel. Univ.
- Fig. 24.—*V. scabrosa* (Tate). Janjukian. R. Murray Cliffs, S.A. Lectotype, right valve. Tate Coll., Adel. Univ.
- Fig. 25.—*V. scabrosa* (Tate). Balcombian. Muddy Creek, lower beds, Vic. Ideotype, right valve. Tate Coll., Adel. Univ.
- Fig. 26.—*V. scabrosa* (Tate). Balcombian. Balcombe Bay, Vic. Plesiotype, left valve (from Tate's tablet of *polynema*). Tate Coll., Adel. Univ.
- Fig. 27.—*V. scabrosa*, var. *polynema* (Tate). Balcombian. Balcombe Bay, Vic. Holotype, left valve. Tate Coll., Adel. Univ.
- Fig. 28.—*V. scabrosa*, var. *polynema* (Tate). Balcombian. Balcombe Bay, Vic. Metatype, right valve. Tate Coll., Adel. Univ.
- Fig. 29.—*V. scabrosa*, var. *polynema* (Tate). Balcombian. Balcombe Bay, Vic. Plesiotype, left valve (from Tate's tablet of *scabrosa*). Tate Coll., Adel. Univ.
- Fig. 30.—*V. janjukiensis*, sp. nov. Janjukian. Bird Rock Cliffs, Torquay, Vic. Holotype, right valve. Nat. Mus.; coll. and pres. F. A. Singleton. (a) exterior; (b) interior, [13474]
- Fig. 31.—*V. janjukiensis*, sp. nov. Janjukian. Bird Rock Cliffs, Torquay, Vic. Paratype, right valve (from Tate's tablet labelled *polynema*). Tate Coll., Adel. Univ.





ART. XII.—*On a Limestone containing Lepidocyclina and other Foraminifera from the Cape Range, Exmouth Gulf, W.A.*

By FREDERICK CHAPMAN, A.L.S., F.R.M.S., &c.

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(With Plate XII.)

[Read 9th December, 1926.]

Contents.

- I. INTRODUCTORY REMARKS.
- II. DESCRIPTION OF THE ROCK.
- III. CONDITIONS OF DEPOSITION.
- IV. SYSTEMATIC LIST AND DESCRIPTION OF THE FAUNA.
- V. BIBLIOGRAPHY.

I. Introductory Remarks.

Although various species of the genus *Lepidocyclina* are well-known components of Australian Tertiary limestones, there have hitherto been no records of *Lepidocyclina dilatata* Michelotti, a species which belongs to the group having a tangential embryonic megasphere. It was, therefore, extremely interesting to receive from Mr. W. S. Dun, of the Department of Mines, Sydney, several specimens of limestone containing these and other foraminifera which had been collected from cliffs of whitish or cream-coloured limestone from the Tertiary rocks of the "Cape Range," south from North West Cape, 25 miles N.W. of Exmouth Gulf Station Homestead, in a deep gorge.

Dr. F. G. Clapp, who collected the specimens, has already published a valuable and extremely interesting paper entitled "A Few Observations on the Geology and Geography of North-West and Desert Basins, Western Australia" (Clapp, 1925). His remarks on this particular limestone deposit may here be quoted with advantage (loc. cit., pp. 64, 65):

"The 'Cape Range' Formation.

"The most unexpected discovery of any relation to the Tertiary system was in the 'Cape Range,' extending south from North-West Cape, where white limestones and interstratified chalky beds form a great anticline rising from below sea-level on the west side of Exmouth Gulf to a height of over 1000 feet in the centre of the Range . . . intersected by deep gorges extending back miles into it. Some beds of the chalky material are full

of foraminifera, as yet unidentified, and only surmised to be of Tertiary age."

Then follows a footnote dated 29th March, 1925;—"Word has just been received from Professor Sir T. W. E. David that Mr. F. Chapman states emphatically that these foraminifera are Oligocene types of *Lepidocyclina* and *Cycloclypeus*. The above is therefore an important discovery of raised and flexed Oligocene limestones in Western Australia.—Ed."

Dr. Clapp continues his description as follows:—

"The east dips vary from nil on top of the Range to 8 degrees on the lower east flank. Far up a gorge in the range, at a point 15 miles south of North-West Cape, I saw the dip flatten out and then dip toward the west at an angle of 2 degrees; but the Gorge was not followed farther west. Rocks are also reported to dip seawards at Pt. Cloates, 75 miles south of North-West Cape, on the west side of the Range." Dr. Clapp adds: "East of the anticline of Cape Range other anticlines were found, one of which, on Giralalia Station, 20 miles east of Cape Range, has a height of at least 300 feet and a breadth of 10 miles."

From the above notes by Dr. Clapp it will be seen that the Oligocene formation is quite extensively developed on the West Coast of Australia, the discovery of which came too late to incorporate in the text of the paper on "The Tertiary Deposits of Australia" by F. A. Singleton and myself, published in the *Proceedings of the Pan-Pacific Science Congress*, Australia, 1923, where we remark (p. 991): "In the absence of palaeontological evidence, however, it is not always possible to make a distinction between Tertiary strata and the formation known as the Coastal Limestone, consisting of consolidated sand-dunes of Post-Tertiary age, which is extensively developed along the western and south-western coasts of Western Australia." The approximate location of the present occurrence was, however, inserted in the accompanying map, facing p. 991.

II. Description of the Rock.

This limestone is, in most samples submitted, moderately friable, but in others too hard to be disintegrated by immersion or crushing in water. It breaks with a ragged surface. The colour varies from a pale cream to yellowish, or sometimes pink, on the older weathered surfaces. The larger foraminifera are conspicuous throughout the rock, and are exposed by fracture of the surface.

An examination of the finer constituents of the limestone shows coccoliths to be fairly abundant; they measure $16\ \mu$ in diameter. There is a small dark nuclear spot in the middle of the disc, a wide, clear or radiately striate zone and a thin outer ring. Rhafidoliths are also numerous, appearing as rod-like bodies, either fusiform or with swollen ends; they measure circ. $39\ \mu$. Flakes of shelly material are abundant, also rhomb crystals of secondary calcite or perhaps dolomite, circ. $20\ \mu$ in diameter.

Fragments of echinoid tests and spines are recognisable in these washings.

The finer washings also contain many minute foraminiferal tests, which have otherwise escaped corrosion.

The medium or coarser washings show abundant foraminiferal remains, but many, especially those belonging to the more coarsely perforated genera, as *Gypsina* and *Lepidocyclina*, have been corroded. This partial solution of the organisms has given rise to the secondary calcite crystals so freely scattered through the mud or finer portions of the limestone.

The larger foraminifera, as *Lepidocyclina* and *Cycloclypeus*, appear to occur in certain bands, especially in the finer, cream-coloured limestone; whilst the yellowish limestone is more prolific in the smaller kinds of foraminifera, as *Anomalina*, *Truncatulina* and *Discorbina*.

III. Conditions of Deposition.

The assemblage of foraminifera met with in this limestone or marly limestone of Exmouth Gulf, indicates a sub-tropical to tropical phase of deposition and comparable to that of a moderately deep water coral sand formation.

The conspicuous element in this fauna consists of abundant tests of the discoidal kinds of foraminifera, and this indicates shallow to moderately deep water. This type of foraminiferal deposit is comparable to that prevailing round coral islands at the present day, as, for example, at Funafuti, in the South Pacific, where *Cycloclypeus* was similarly abundant at about 50 to 200 fathoms.

The smaller foraminifera here present include numerous *Miliolinae*, the minute arenaceous forms such as *Spiroplecta*, *Bolivina* and *Cassidulina*, and the lagenids, as *Nodosaria* and *Cristellaria*, which are usual concomitants of clear water at fair depths. The open water character of the deposit is also indicated by the presence of the pelagic forms, as *Globigerina*.

IV. Systematic List and Description of the Fauna.¹

Phylum PROTOZOA.

Class RHIZOPODA.

Order FORAMINIFERA.

Fam. MILIOLIDAE.

Sub-fam. MILIOLININAE.

Genus *Biloculina* d'Orbigny.

BILOCULINA BULLOIDES d'Orbigny.

Biloculina bulloides d'Orbigny, 1826, p. 297, pl. xvi., f. 1-4.
 Schlumberger, 1887, p. 120, pl. xv., f. 10-13. Chapman,
 1907, p. 13, pl. i., f. 3, 4.

1.—My best thanks are due to Mr. W. J. Farr for much painstaking work in selecting a large part of the smaller foraminifera herein recorded.

Observations.—This well-known recent species has a geological range in Australia extending down to the Oligocene (Muddy Creek and Port Phillip). The tests vary in outline from slightly elongate or sub-oval to sub-circular.

Occurrence.—Frequent; small.

Genus *Miliolina* Williamson.

MILIOLINA OBLONGA (Montagu).

Vermiculum oblongum Montagu, 1803, p. 522, pl. xiv., f. 9.

Triloculina oblonga (Mont.), Cushman, 1917, p. 69, pl. xxxvi., f. 3.

Observations.—This species has a long geological range. It is found in various Tertiary deposits in Victoria, notably at Muddy Creek and Port Phillip (Balcombian). It is also a well-known recent species.

Occurrence.—Frequent; rather small.

MILIOLINA PYGMAEA (Reuss).

Quinqueloculina pygmaea Reuss, 1850, p. 384, pl. i., f. 3a,b.

Miliolina pygmaea (Reuss), Brady, 1884, p. 163, pl. cxiii., f. 16a,b.

Miliolina oblonga Chapman (*non Serpula oblonga*, Mont.), 1907, p. 17, pl. ii., f. 26.

Observations.—This is a minute species of the *M. seminulum* type, but with more numerous chambers. It is trigonal in cross section. As a recent form it inhabits deeper water than other miliolines, as was remarked by Dr. H. B. Brady. It has occurred as a fossil in the Miocene of the Vienna Basin and in the Oligocene of Port Phillip, Victoria.

Occurrence.—Very rare.

MILIOLINA SEMINULUM (Linné).

Serpula seminulum Linné, 1767, No. 791. Id., 1788, p. 3739, No. 2.

Miliolina seminulum (L.), Brady, 1884, p. 157, pl. v., f. 6a-c. Chapman, 1907, p. 19, pl. ii., f. 34.

Observations.—A common, fairly shallow water form. It occurs abundantly in the Victorian Mid-Tertiary series.

Occurrence.—Frequent; small.

MILIOLINA TRIGONULA (Lamarck).

Miliolites trigonula Lamarck 1804, p. 351, No. 3; 1822, p. 612, No. 3.

Miliolina trigonula (Lamarck), Chapman, 1907, p. 18, pl. ii., f. 30.

Triloculina trigonula (Lam.), Cushman, 1917, p. 65, pl. xxv., f. 3.

Observations.—This species has already been recorded fossil from the Australian Tertiary beds of Port Phillip (Oligocene).

Occurrence.—Rare, typical.

Fam. LITUOLIDAE.

Subfam. LITUOLINAE.

Genus *Reophax* Montfort.

REOPHAX SCORPIURUS Montfort.

Reophax scorpiurus Montfort, 1808, p. 330, 83^{me} genre. Cushman, 1910, p. 83, text-figs. 14-16 (p. 84).

Observations.—A commonly distributed species, both fossil and recent.

Occurrence.—Very rare; a stout, obtuse form.

Genus *Haplophragmium* Reuss.

HAPLOPHRAGMIUM ROTULATUM Brady.

Haplophragmium rotulatum Brady, 1884, p. 306, pl. xxxiv., f. 5, 6. Cushman, 1910, p. 104, text-figs. 156, 157.

Observations.—This species was hitherto known only as a recent form. It is interesting to note the present occurrence in beds as far back as the Oligocene.

Occurrence.—Very rare.

HAPLOPHRAGMIUM SUBGLOBOSUM (G. O. Sars).

Lituola subglobosa G. O. Sars, 1872, p. 253.

Haplophragmium latidorsatum Brady (*non* Bornemann), 1884, p. 307, pl. xxxiv., f. 7, 8, 10, ?14.

Haplophragmium subglobosum (G. O. Sars), Cushman, 1910, p. 105, text-figs. 162-164 (p. 106).

Observations.—This is a common species, both fossil and recent.

Occurrence.—Very rare.

Fam. TEXTULARIIDAE.

Sub-fam. TEXTULARIINAE.

Genus *Textularia* Defrance.

TEXTULARIA GRAMEN d'Orbigny.

Textularia gramen d'Orbigny, 1846, p. 248, pl. xv., f. 4-6. Chapman, 1907, p. 25, pl. iii., f. 53. Cushman, 1911, p. 8, text-figs. 6-8. Chapman, 1926, p. 30, pl. ii., f. 19; pl. v., f. 20a-c.

Observations.—The solitary specimen found has the aboral end slightly damaged, but, so far as can be seen, it shows no indi-

cation of a spiroplectine commencement. It is a well distributed form, both recent and fossil.

Occurrence.—Very rare.

Genus *Spiroplecta* Ehrenberg.

SPIROPLECTA NUSSDORFENSIS (d'Orbigny).

Textularia nussdorfensis d'Orbigny, 1846, p. 243, pl. xiv., f. 17-19.

Spiroplecta nussdorfensis (d'Orb.), Chapman, 1907, p. 28, pl. iii., f. 62.

Observations.—This form occurs in the Miocene of the Vienna Basin and the Oligocene of Grice's Creek, Port Phillip. The present example is typical.

Occurrence.—Very rare.

Genus *Verneuilina* d'Orbigny.

VERNEUILINA TRIQUETRA (Münster).

Textularia triquetra Münster, 1838, p. 384, pl. iii., f. 19.

Verneuilina triquetra (Münst.), Brady, 1884, p. 383, pl. xlvii., f. 18-20.

Observations.—In the fossil condition this species occurs both in the Cretaceous and Tertiary. As a living form it inhabits fairly deep water.

Occurrence.—Rare.

Genus *Guembelina* Egger.

GUEMBELINA POLYSTROPHA (Reuss).

Bulimina polystropha Reuss, 1845-6, p. 109, pl. xxiv., f. 53.

Guembelina polystropha (Reuss), Egger, 1899, p. 34, pl. xiv., f. 31-34, 40. Chapman, 1917, p. 21, pl. ii., f. 19.

Observations.—The example found here is rather more elongate than usual; otherwise it is typical. It occurred in some abundance in the Gingsin Chalk of W.A., and it is here evidently a survival of that fauna.

Occurrence.—Very rare.

Sub-fam. BULIMININAE.

Genus *Bulimina* d'Orbigny.

BULIMINA ELEGANS d'Orbigny.

Bulimina elegans d'Orbigny, 1826, p. 270, No. 10; Modèles, No. 9. Cushman, 1911, p. 82, text-figs. 134a-c.

Observations.—A small but otherwise typical specimen occurs here. It is a Cretaceous and Tertiary fossil species, and was found in Victoria in the Tertiary (Janjukian) beds of the Mallee Bore (Bore 11, 442-444 feet).

Occurrence.—Very rare.

Genus *Bolivina* d'Orbigny.*BOLIVINA NOBILIS* Hantken.

Bolivina nobilis Hantken, 1875, p. 56, pl. xv., f. 4. Chapman, 1892, p. 516, pl. xv., f. 11. Cushman, 1911, p. 39, text-fig. 64a,b.

Observations.—The first appearance of this form seems to be in the Cretaceous. It has been found in the Oligocene of Hungary and in succeeding beds in Europe, and also in the Miocene of the Victorian Mallee Bores. As a recent form it, curiously, is confined to the South Pacific.

Occurrence.—Very rare.

BOLIVINA SPIROPLECTIFORMIS, sp. nov.

(Plate XII., Fig. 4.)

Description.—Test small, elongate, depressed, with sharp but not carinate margins. The first third of the test is a coiled spiral of about six chambers, including a small central sphere, and this is succeeded by five alternate chambers as in *Bolivina limbata*. The spiral series and the next chamber show re-entrant angulation at place of contact, the angulation directed distally.

Dimensions.—Length, 0.42 mm.; width, 0.173 mm.

Observations.—The resemblance of this form to *B. limbata* is very close, but it differs materially in the coiled commencement. It appears to link up the hyaline bolivine forms with the strictly arenaceous *Spiroplecta*, to a species of which, *S. bififormis* (Parker and Jones) (see Brady, 1884, pl. xlv., f. 25-27), it bears some resemblance.

BOLIVINA PUNCTATA d'Orbigny.

Bolivina punctata d'Orbigny, 1839, p. 63, pl. viii., f. 10-12. Chapman, 1907, p. 32, pl. iv., f. 80. Cushman, 1911, p. 32, text-figs. 53a,b. Chapman, 1926, p. 40, pl. i. f. 7.

Observations.—A typical specimen was found in the finer washings, which shows the slight curvature at the aboral end, seen in other specimens. It occurs in the Oligocene of Victoria and in the Upper Eocene and Lower Miocene of New Zealand.

Occurrence.—Very rare.

BOLIVINA TEXTILARIOIDES Reuss.

Bolivina textilarioides Reuss, 1862, p. 81, pl. x., f. 1. Brady, 1884, p. 419, pl. liii., f. 23-25. Chapman, 1907, p. 31, pl. iv., f. 79. Idem, 1926, p. 41, pl. ix., f. 8.

Observations.—This species commences its geological history, so far as recorded, in the Lower Cretaceous. It is found in the Oligocene of Victoria and the Upper Eocene, Miocene and Pliocene of New Zealand.

Occurrence.—Very rare.

Sub-fam. CASSIDULININAE.

Genus *Cassidulina* d'Orbigny.

CASSIDULINA CALABRA (Seguenza).

Burseolina calabra Seguenza, 1880, p. 138, pl. xiii., f. 7a,b.

Cassidulina calabra (Seg.), Brady, 1884, p. 431, pl. cxiii., f. 8a-c.

Chapman, 1926, p. 42, pl. ix., f. 12.

Observations.—The original geological horizon for this species is Upper Miocene. I have since recorded it from the Upper Eocene and the Lower Miocene of New Zealand.

Occurrence.—Frequent.

CASSIDULINA SUBGLOBOSA Brady.

Cassidulina subglobosa Brady, 1884, p. 430, pl. liv., f. 17a-c.

Chapman, 1907, p. 33, pl. iv., f. 84. Idem, 1926, p. 42, pl. ix., f. 14.

Observations.—The range of this species in fossil deposits commences in the Lower Cretaceous. It is a common form in the Victorian Oligocene and Miocene, and I have lately described it from the Upper Eocene and Lower Miocene of New Zealand.

Occurrence.—Very rare.

Fam. LAGENIDAE.

Sub-fam. LAGENINAE.

Genus *Lagena* Walker and Boys.

LAGENA HISPIDA Reuss.

Lagena hispida Reuss, 1863, p. 335, pl. vi., f. 77-79. Chapman, 1926, p. 45, pl. x., f. 1.

Observations.—Fossil specimens date from the Lias. It is found in the Oligocene of Victoria, and in the Upper Eocene and Upper Miocene of New Zealand. It is a fairly deep water form.

Occurrence.—Very rare.

Sub-fam. NODOSARIINAE.

Genus *Nodosaria* Lamarck.Sub-genus *Dentalina* d'Orbigny.

NODOSARIA (D.) CONSOBRINA (d'Orbigny).

Dentalina consobrina d'Orbigny, 1846, p. 46, pl. ii., f. 1-3.

Nodosaria (*Dentalina*) *consobrina* (d'Orbigny), Brady, 1884, p. 501, pl. lxii., f. 23, 24. Chapman, 1926, p. 48, pl. i. f. 1-3; pl. iii., f. 27, 33, 34.

Observations.—Common throughout the Cretaceous and Tertiary, this species occurs in the Oligocene and Miocene of Victoria, and in the Upper Eocene and Miocene of New Zealand.

Occurrence.—Very rare.

NODOSARIA (D.) OBLIQUA (Linné).

Nautilus obliquus Linné, 1767, p. 1163.

Nodosaria (Dentalina) obliqua (L.), Brady, 1884, p. 513, pl. lxiv., f. 20-22. Chapman, 1917, p. 26, pl. iv., f. 39. Idem, 1926, p. 49, pl. iii., f. 23, 24, 37-39.

Observations.—This is quite a common species in the Oligocene and Miocene of Victoria. It has lately been recorded as of Upper Eocene and Lower Miocene ages in New Zealand.

Occurrence.—Very rare.

NODOSARIA SUBTERTENUATA Schwager.

Nodosaria subtertenuata Schwager, 1866, p. 235, pl. vi., f. 74. Brady, 1884, p. 507, pl. lxii., f. 7, 8. Howchin, 1894, p. 364. Chapman, 1917, p. 27, pl. xii., f. 117.

Observations.—Schwager's original specimens came from the Pliocene of Kar-Nicobar. Subsequently it was obtained off Japan by the "Challenger" (Brady); and later it was discovered in Cretaceous beds in South and West Australia (Howchin and Chapman). It therefore appears to have originated in the Australian area and to have persisted here until Oligocene times.

Occurrence.—Very rare and small.

NODOSARIA LONGISCATA d'Orbigny.

Nodosaria longiscata d'Orbigny, 1846, p. 32, pl. i., f. 10-12. Sherborn and Chapman, 1889, p. 486, pl. xi., f. 17, 18. Chapman, 1926, p. 51, pl. xi., f. 7.

Observations.—This is a Tertiary species, dating from the Eocene. It has lately been found in the Upper Eocene of New Zealand.

Occurrence.—Rare; typical.

Genus *Frondicularia* Defrance.

FRONDICULARIA cf. DECHENI Reuss.

Frondicularia decheni Reuss, 1860, p. 191, pl. iv. f. 3. Perner, 1897, p. 67, pl. iii., f. 3; pl. v., f. 6, 15. Chapman, 1917, p. 30, pl. vi., f. 53.

Observations.—The present example is of somewhat irregular growth, but it agrees in the almost parallel edges and the striate surface. This species has hitherto been known as a Cretaceous fossil, both in Europe and Australia. Here it therefore persists to the Oligocene.

Occurrence.—Very rare.

Genus *Trifarina* Cushman.

TRIFARINA BRADYI Cushman.

Rhabdogonium tricarimatum Brady (non d'Orbigny), 1884, p. 525, pl. lxvii., f. 1-3.

Triplasia tricarinatum (d'Orbigny), Cushman, 1913, p. 62, pl. xxxix., f. 2.

Rhabdogonium tricarinatum (d'Orbigny), Heron-Allen and Earland, 1923, p. 158.

Trifarina bradyi Cushman, 1923, p. 99, pl. xxii., f. 3-9.

Observations.—It has been pointed out by Cushman that the recent species resembling *Rhabdogonium* of the Cretaceous, in general aspect, are distinct from d'Orbigny's generic type in having affinities with *Uvigerina*. The present Oligocene occurrence compares with the recent rather than the Cretaceous form, and it has also been met with in the Oligocene of Port Phillip, Victoria.

Occurrence.—Rare; typical.

Genus *Marginulina* d'Orbigny.

MARGINULINA BULLATA REUSS.

Marginulina bullata Reuss, 1845-6, p. 29, pl. xiii., f. 34-38. Chapman, 1926, p. 56, pl. iii., f. 48.

Observations.—This form is an inflated modification of *M. glabra*. It is common in the Cretaceous and Lower Tertiaries, and has occurred in the Upper Eocene, in New Zealand.

Occurrence.—Very rare.

MARGINULINA COSTATA (Batsch).

Nautilus costatus Batsch, 1791, pl. i., f. 1a-g.

Marginulina costata (Batsch), Brady, 1884, p. 528, pl. lxx., f. 10-13. Sherborn and Chapman, 1889, p. 487, pl. xi., f. 28. Chapman, 1917, p. 26, pl. vii., f. 63, 64. Idem, 1926, p. 56, pl. iii., f. 49, 51, 54.

Observations.—This species occurs in all formations from the Lias upwards. It has been found in the Cretaceous of Gingin, W.A.; in the Oligocene of Port Phillip, Victoria; and in the Upper Eocene of New Zealand.

Occurrence.—Very rare.

MARGINULINA GLABRA d'Orbigny.

Marginulina glabra, d'Orbigny, 1826, p. 259, No. 6; Modèles, No. 55. Brady, 1884, p. 527, pl. lxx., f. 5, 6. Chapman, 1917, p. 33, pl. vii., f. 65. Cushman, 1923, p. 127, pl. xxxvi., f. 5, 6. Chapman, 1926, p. 57, pl. iii., f. 46a,b, 47a,b.

Observations.—The present example is a large and stout form. It is comparable with specimens found in the Oligocene and Miocene of Victoria. In New Zealand it occurs fossil in the Upper Eocene. It was also recorded from the chalk of Gingin, W.A.

Occurrence.—Very rare.

Genus *Vaginulina* d'Orbigny.

VAGINULINA LEGUMEN (Linné).

Nautilus legumen Linné, 1767, p. 1164, No. 288.

Vaginulina legumen (L.), Chapman, 1917, p. 33, pl. viii., f. 67.

Idem, 1926, p. 58, pl. i., f. 2.

Observations.—The vaginuline forms of this roundly depressed smooth type are common in Mesozoic and Lower Tertiary strata, and found more rarely in later deposits. It occurs with more frequency in the Oligocene and Miocene of Victoria, and in the Upper Eocene of New Zealand; also in the Cretaceous of Gingin.

Occurrence.—Common.

Genus *Cristellaria* Lamarck.

CRISTELLARIA BRONNI (Römer).

Planularia bronni (Römer), Reuss, 1862, p. 70, pl. vii., f. 13a,b.

Chapman, 1894, p. 649, pl. ix., f. 12a,b, 13a,b. Idem, 1917, p. 36, pl. viii., f. 77.

Observations.—This species is another of the hitherto Cretaceous types which has persisted into Oligocene times. It is closely comparable to the Gingin examples.

Occurrence.—Very rare.

CRISTELLARIA WETHERELLII (Jones).

Marginulina sp., Sowerby, 1834, p. 134, pl. ix., f. 12.

Marginulina wetherellii Jones, 1854, p. 37. Parker and Jones, 1859, p. 350.

Marginulina fragraria Gümbel, 1870 (1868), p. 635, pl. i., f. 58a-c.

Cristellaria wetherellii (Jones), Chapman, 1926, p. 66, pl. iv., f. 4a,b, 5a,b.

Observations.—*C. wetherellii* is a well-known species in the Lower Eocene (London Clay) in the Oligocene of Hungary, and the Middle Eocene of Bavaria. In New Zealand it is found in the Upper Eocene. In recent soundings it has been dredged at 155 and 350 fathoms.

Occurrence.—Common.

CRISTELLARIA ACULEATA d'Orbigny.

Cristellaria aculeata d'Orbigny, 1826, p. 292, No. 14. Brady, 1884, p. 555, pl. lxxxii., f. 4, 5. Chapman, 1926, p. 58, pl. xii., f. 6.

Observations.—The present form is of the similar tuberculate variety found in the Upper Eocene of New Zealand. It was originally recorded from the Pliocene of Siena, and is a living species in West Indian Seas.

Occurrence.—Very rare.

CRISTELLARIA GIBBA d'Orbigny.

Cristellaria gibba d'Orbigny, 1826, p. 292, pl. xxiii., f. 14*a,b*.
Chapman, 1917, p. 37, pl. ix., f. 82. Idem, 1926, p. 61, pl. iv., f. 14*a,b*.

Observations.—The history of this species commences in the Lower Cretaceous (Aptian) of Surrey, England; it occurs at the base of the Upper Cretaceous (Hils) in Germany; and in the Gingin Chalk of W. Australia. In New Zealand *C. gibba* is a fairly common form in the Upper Eocene. Its range extends through the Tertiary, and it is a living form in shallow to moderately deep water.

Occurrence.—Very rare.

CRISTELLARIA OVALIS Reuss.

Cristellaria ovalis Reuss, 1845-6, p. 34, pl. viii., f. 9*a,b*; pl. xii., f. 19*a,b*; pl. xiii., f. 60*a*-63*b*. Howchin, 1907, p. 42. Chapman, 1917, p. 35, pl. viii., f. 75.

Observations.—This is one of the *C. gibba* type, but having a more depressed shell. It has hitherto been regarded as a Gault and Cenomanian fossil, but was also found in the Chalk of Gingin.

Occurrence.—Very rare.

CRISTELLARIA ORBICULARIS (d'Orbigny).

Robulina orbicularis d'Orbigny, 1826, p. 288, pl. xv., f. 8, 9.

Cristellaria orbicularis (d'Orb.), Brady, 1884, p. 549, pl. lxix., f. 17. Howchin, 1907, p. 42. Chapman, 1926, p. 63, pl. iv., f. 20*a,b*.

Observations.—Professor Howchin found this species in the Chalk of Gingin, W.A. It occurs throughout the Cainozoic series, and is also an Upper Eocene form in New Zealand.

Occurrence.—Very rare.

CRISTELLARIA CULTRATA (Montfort).

Robulus cultratus Montfort, 1808, p. 215, 54^{me} genre.

Cristellaria cultrata (Montf.), Brady, 1884, p. 550, pl. lxx., f. 4-8. Chapman, 1926, p. 61, pl. i., f. 6; pl. iv., f. 9*a,b*, 15*a,b*, 27*a,b*, 30*a,b*, 31.

Observations.—This species is found in almost all fossil deposits, from the Lias to the present day. It is found in shallow to moderately deep water. The Australian occurrences are in the Cretaceous (Gingin), and in Oligocene beds (Port Phillip). In New Zealand *C. cultrata* was found in the Upper Cretaceous, Upper Eocene and Miocene.

Occurrence.—Common.

Genus *Flabellina* d'Orbigny.

FLABELLINA RUGOSA d'Orbigny.

Flabellina rugosa d'Orbigny, 1840, p. 23, pl. ii., f. 4, 5, 7. Reuss, 1845-6, p. 33, pl. viii., f. 31-34; pl. xiii., f. 49, 53. Perner, 1897, p. 72, pl. v., f. 10, 16, 17, 19. Chapman, 1917, p. 39, pl. x., f. 90.

Observations.—This is a most interesting survivor of the Cretaceous fauna. It was met with in the Cretaceous of Gingen, where it is moderately common.

Occurrence.—Very rare.

Sub-fam. POLYMORPHININAE.

Genus *Polymorphina* d'Orbigny.

POLYMORPHINA COMMUNIS d'Orbigny.

Polymorphina (Guttulina) communis d'Orbigny, 1826, p. 266, pl. xii., f. 1-4; Modèle, No. 62.

Polymorphina communis d'Orbigny, Brady, 1884, p. 568, pl. lxxii. f. 19. Chapman, 1917, p. 41, pl. x., f. 95. Idem, 1926, p. 67, pl. v., f. 7a,b.

Observations.—This species has an extended geological range. In Australia it occurs in both Oligocene and Miocene, as well as in the Cretaceous. In New Zealand it has been noted from the Eocene and Miocene.

Occurrence.—Frequent.

POLYMORPHINA OBLONGA d'Orbigny.

Polymorphina oblonga d'Orbigny, 1846, p. 232, pl. xii., f. 29-31. Cushman, 1913, p. 88, pl. xxxvii., f. 6. Chapman, 1926, p. 68, pl. xiv., f. 2.

Observations.—This form is quite a common one in the Oligocene and Miocene of Victoria. It has also occurred in the Oligocene of Kakanui, New Zealand.

Occurrence.—Frequent.

Genus *Siphogenerina* Schlumberger.

SIPHOGENERINA COLUMELLARIS (Brady).

Sagrina columellaris Brady, 1884, p. 591, pl. lxxv., f. 15-17.

Siphogenerina columellaris (Brady), Egger, 1893, p. 316, pl. ix., f. 28, 31, 33. Cushman, 1913, p. 104, pl. xlvii., f. 2, 3.

Observations.—The occurrence here of this species places it much further back in the geological record than hitherto, since it has not before been found in the Australian Tertiaries.

Occurrence.—Very rare.

SIPHOGENERINA BIFRONS (Brady).

Sagrina bifrons Brady, 1884, p. 582, pl. lxxv., f. 18-20.

Siphogenerina (*Sagrina*) *bifrons* (Brady), Egger, 1893, p. 317, pl. ix., f. 25, 26, 29.

Siphogenerina bifrons (Brady), Cushman, 1913, p. 105, pl. xlv., f. 1, 2, 5-7.

Observations.—This seems to be the first fossil occurrence of the above species. It is well distributed in the Pacific and along the Australian Coast. The present examples are megalospheric.

Occurrence.—Rare.

Fam. GLOBIGERINIDAE.

Genus *Globigerina* d'Orbigny.

GLOBIGERINA BULLOIDES d'Orb.

Globigerina bulloides d'Orbigny, 1826, p. 277, No. 1, Modèles, Nos. 17, 76. Cushman, 1914, p. 5, pl. ii., f. 7-9, pl. ix. Chapman, 1917, p. 43, pl. xii., f. 1-3. Idem, 1926, p. 72, pl. v., f. 35a-d.

Observations.—The examples found here are well-developed. *G. bulloides* is common in many Australian Tertiary deposits.

Occurrence.—Rare.

Genus *Sphaeroidina* d'Orbigny.

SPHAEROIDINA BULLOIDES d'Orbigny.

Sphaeroidina bulloides d'Orbigny, 1826, p. 267, No. 1, Modèles, No. 65. Cushman, 1914, p. 18, pl. x., f. 7; pl. xii., f. 1. Chapman, 1917, p. 45, pl. xii., f. 127. Idem, 1926, p. 74, pl. xv., f. 2.

Observations.—This species is also of common occurrence in Cretaceous and Tertiary deposits, both in Australia and New Zealand.

Occurrence.—Frequent.

Genus *Pullenia* Parker and Jones.

PULLENIA QUINQUELOBA (Reuss).

Nonionina quinqueloba Reuss, 1851, p. 47, pl. v., f. 31a,b.

Pullenia quinqueloba (Reuss), Brady, 1884, p. 617, pl. lxxxiv., f. 14, 15.

Observations.—The related *P. sphaeroides* is the commoner form of the genus in Australian fossil deposits, but I have also recorded *P. quinqueloba* from the borings in the Mallee.

Occurrence.—Very rare.

Fam. ROTALIIDAE.

Sub-fam. ROTALIINAE.

Genus *Discorbina* Parker and Jones.*DISCORBINA GLOBULARIS* (d'Orbigny).

Rosalina globularis d'Orbigny, 1826, p. 271, pl. xiii., f. 1-4;
Modèle, No. 69.

Discorbina globularis (d'Orb.), Brady, 1884, p. 643, pl. lxxxvi.,
f. 8, 13.

Observations.—*D. globularis* is a well-known Tertiary fossil,
and in recent soundings usually affects shallow waters.

Occurrence.—Very rare.

DISCORBINA ARAUCANA (d'Orbigny).

Rosalina araucana d'Orbigny, 1839, p. 44, pl. vi., f. 16-18.

Discorbina araucana (d'Orb.), Brady, 1884, p. 645, pl. lxxxvi., f.
10, 11.

Observations.—As a living species this form is well known in
southern waters. It has been found in Tertiary beds in the Mallee
Bores.

Occurrence.—Very rare.

DISCORBINA VILARDEBOANA (d'Orbigny).

Rosalina vilardeboana d'Orbigny, 1839, p. 44, pl. vi., f. 13-15.

Discorbina vilardeboana (d'Orb.), Brady, 1884, p. 645, pl. lxxxvi.,
f. 9, 12; pl. lxxxviii. f. 2. Howchin, 1889, p. 12. Chap-
man, 1926, p. 77, pl. xv., f. 10.

Observations.—This species dates from Cretaceous times (Ap-
tian of England), and is also known from the Oligocene of W.
Victoria and from the Upper Eocene of New Zealand.

Occurrence.—Very rare.

Genus *Planorbulina* d'Orbigny.*PLANORBULINA LARVATA* P. and J.var. *INAEQUILATERALIS* Heron-Allen and Earland

Planorbulina larvata P. and J., var. *inaequilateralis*, Heron-Allen
and Earland, 1924, p. 174, pl. xii., f. 85-90.

Observations.—This interesting variety of *P. larvata* was dis-
covered by Heron-Allen and Earland in the marls of the Filter
quarries at Batesford, Victoria, which deposit is of Miocene
(Burdigalian age), and therefore later than the present one from
Exmouth Gulf.

Occurrence.—Very rare.

Genus *Truncatulina* d'Orbigny.

TRUNCATULINA LOBATULA (W. and J.).

Nautilus lobatulus Walker and Jacob, 1798, p. 642, pl. xiv., f. 36.

Truncatulina lobatula (W. and J.), Brady, 1884, p. 660, pl. xcii., f. 10; pl. xciii., p. 78, pl. xv., f. 12.

Observations.—One of the most abundant rotalines in Australian Tertiary and Recent deposits. The present examples are typical.

Occurrence.—Common.

TRUNCATULINA REFULGENS (Montfort).

Cibicides refulgens Montfort, 1808-10, p. 122, 31^{me} genre.

Truncatulina refulgens (Montfort), Brady, 1884, p. 659, pl. xcii., f. 7-9. Chapman, 1926, p. 78, pl. xv., f. 13.

Observations.—This is a common fossil in the Australian and New Zealand Tertiary deposits.

Occurrence.—Rare; typical.

TRUNCATULINA MUNDULA Brady, Parker and Jones.

Truncatulina mundula Brady, Parker and Jones, 1888, p. 228, pl. xlv., f. 25.

Planorbulina mundula B., P. and J., Goës, 1896, p. 71.

Truncatulina mundula, B., P. and J., Cushman, 1915, p. 41, pl. xiii., f. 4 (text-fig. 45a-c).

Observations.—*T. mundula* is a common species in Australian Tertiary marls, and is well represented living in Pacific faunas. The specimens here met with are perhaps rather more sharply keeled than usual.

Occurrence.—Frequent.

TRUNCATULINA WUELLERSTORFI (Schwager).

Anomalina wuellerstorfi Schwager, 1866, p. 258, pl. vii., f. 105, 107.

Truncatulina wuellerstorfi (Schw.), Brady, 1884, p. 662, pl. xciii., f. 8, 9. Chapman, 1917, p. 46, pl. xi., f. 106. Idem, 1926, p. 79, pl. xvi., f. 3.

Observations.—This species was found in the Gingen Chalk of W. Australia, and it is also a common fossil in the Tertiaries. In New Zealand it was found in the Upper Eocene and Miocene.

Occurrence.—Frequent.

Genus *Siphonina* Reuss.

SIPHONINA RETICULATA (Czjzek).

Rotalina reticulata Czjzek, 1848, p. 145, pl. xiii., f. 7-9.

Truncatulina reticulata (Cz.), Brady, 1884, p. 669, pl. xcvi., f. 5-8.

Siphonina reticulata (Cz.), Cushman, 1921, p. 322, pl. lxx., f. 3a-c.

Observations.—This is one of the regular components of the microzoic fauna of the Australian Tertiaries, and ranges from the Oligocene upwards. The present examples are well developed.

Occurrence.—Rare.

Genus *Anomalina* Parker and Jones.

ANOMALINA AMMONOIDES (Reuss).

Rosalina ammonoides Reuss, 1845-6, p. 36, pl. viii., f. 53; pl. xiii., f. 66.

Anomalina ammonoides (Reuss.), Brady, 1884, p. 672, pl. xciv., f. 2, 3. Chapman, 1926, p. 79, pl. v., f. 31a-c, 34a-c.

Observations.—One of the most abundant of the Tertiary Foraminifera in Australia, this species is here represented by well grown examples.

Occurrence.—Frequent.

ANOMALINA GROSSERUGOSA (Gümbel).

Truncatulina grosserugosa Gümbel, 1870, p. 660, pl. ii., f. 104.

Anomalina grosserugosa (Gümbel), Cushman, 1915, p. 45, pl. xx., f. 1. Chapman, 1926, p. 80, pl. xvi., f. 5.

Observations.—This fairly deep water form is a common species in the Tertiary deposits of Australia and New Zealand.

Occurrence.—Common. Rather small.

Genus *Carpenteria* Gray.

CARPENTERIA PROTEIFORMIS Goës.

Carpenteria balaniformis Gray, var. *proteiformis* Goës, 1882, p. 94, pl. vi., f. 208-14; pl. vii., f. 215-219.

Carpenteria proteiformis Goës, Brady, 1884, p. 679, pl. xcvii., f. 8-14. Chapman, 1926, p. 81, pl. xvi., f. 7.

Observations.—This is a common Oligocene species in Australia and New Zealand. It also occurs in the Miocene of the Victorian Mallee Bores and Batesford.

Occurrence.—Rare.

Genus *Rotalia* Lamarck.

?*ROTALIA CALCAR* (d'Orbigny).

Calcarina calcar d'Orbigny, 1826, p. 276, No. 1, Modèle, No. 34.

Rotalia calcar (d'Orbigny), Brady, 1884, p. 709, pl. cviii., f. 3, ?4.

Observations.—There is a worn test of a foraminifer in these washings, which is referred, provisionally, to this species. *R. calcar* is a well known form in the Australian Tertiary limestones.

Occurrence.—Very rare.

Genus **Calcarina** d'Orbigny.CALCARINA DEFRANCI *d'Orbigny*.

Calcarina defrancii d'Orbigny, 1826, p. 276, No. 3, pl. xiii., f. 5-7.
Rotalia calcar Chapman, 1909. (*non d'Orb.*), p. 289, pl. iii., f. 2.
Calcarina defrancii d'Orb., Heron-Allen and Earland, 1924, p. 182.

Observations.—This is a common species in the Miocene of Batesford, Victoria. Although there accompanied by *Rotalia calcar*, my figures were erroneously referred to the latter species, as pointed out by Heron-Allen and Earland.

Occurrence.—Rare. Rather worn examples.

Genus **Baculogypsina** Sacco.

BACULOGYPSINA SPHAERULATA (Parker and Jones).

Orbitolina sphaerulata Parker and Jones, 1860, p. 33, No. 8.
Tinoporus baculatus Carpenter (*non* Montfort), 1861, p. 577, pls. xviii., xxi.
Baculogypsina sphaerulatus (P. and J.), Cushman, 1919, pl. xlv., f. 6. Idem, 1921, p. 359, pl. lxxv., f. 6.

Observations.—This is an abundant species in all warm waters of Australia and the Pacific. It is extremely interesting to find it fossil and so far down in the Tertiary series.

Occurrence.—Very rare; small, but otherwise typical.

Genus **Gypsina** Carter.

GYPSINA GLOBULUS (Reuss).

Cerriopora globulus Reuss, 1847, p. 33, pl. v., f. 7.
Gypsina globulus (Reuss), Heron-Allen and Earland, 1924, p. 183, pl. xiv., f. 117, 118.

Observations.—*G. globulus* is quite an abundant form in Australian Tertiary deposits, and as a recent form it affects coral zones.

Occurrence.—Rare; typical.

Fam. NUMMULITIDAE

Sub-fam. POLYSTOMELLINAE.

Genus **Polystomella** Lamarck.

POLYSTOMELLA CRATICULATA (Fichtel and Moll).

Nautilus craticulatus Fichtel and Moll, 1798, p. 51, pl. v., f. h-k.
Polystomella craticulata (F. and M.), Brady, 1884, p. 739, pl. cx., f. 16, 17. Howchin, 1889, p. 16.

Observations.—This is also a coral reef species. It occurs in the Oligocene and Lower Pliocene of Muddy Creek, and in the basal Miocene of the Mallee Bores, both in Victoria.

Occurrence.—Very rare.

Sub-fam. NUMMULITINAE.

Genus *Amphistegina* d'Orbigny.

AMPHISTEGINA LESSONII d'Orbigny.

Amphistegina lessonii d'Orbigny, 1826, p. 304, No. 3, pl. xvii., f. 1-4; Modèle, No. 98. Chapman, 1926, p. 90, pl. i., f. 19.

Observations.—*A. lessonii* is a universally distributed and abundant form in the Australian and New Zealand Tertiaries.

Occurrence.—Very rare.

Genus *Operculina* d'Orbigny.

OPERCULINA COMPLANATA (Defrance).

Lenticulites complanata Defrance, 1822, p. 453.

Operculina complanata (Defr.), Brady, 1884, p. 743, pl. cxiii., f. 3-5, 8. Chapman, 1926, p. 91, pl. xviii., f. 1; pl. xix., f. 3.

Observations.—This is a common Tertiary foraminifer. Several fragments of this form were found in the washings from the Cape Range limestone.

Occurrence.—Frequent.

Genus *Heterostegina* d'Orbigny.

HETEROSTEGINA DEPRESSA d'Orbigny.

Heterostegina depressa d'Orbigny, 1826, p. 305, No. 2, pl. xvii., f. 5-7; Modèle No. 99. Chapman, 1910, p. 295. Idem, 1926, p. 92, pl. xviii., f. 2.

Observations.—This is one of the fairly common forms in the Miocene of Australia and New Zealand.

Occurrence.—Frequent.

Sub-fam. CYCLOCYPEINAE.

Genus *Cyclocypeus* Carpenter.

CYCLOCYPEUS PUSTULOSUS Chapman.

(Plate XII., Figs. 1, 3.)

Cyclocypeus pustulosus Chapman, 1905, p. 271, pl. v., f. 1; pl. vi., f. 2; pl. vii., f. 2. Idem, 1909, p. 295, pl. lii., f. 6; pl. lv., f. 4. Id., 1926, p. 92, pl. xviii., f. 3a,b.

Observations.—This species appears to have a somewhat extended range, from Oligocene to Miocene. The present examples are very large, sometimes measuring as much as 20 mm. in diam-

eter. The holotype, from the New Hebrides, measures only 6 mm. in diameter. Both are probably microspheric.

Occurrence.—Common.

Genus **Lepidocyclina** Gumbel.

Sub-genus **Eulepidina** H. Douvillé.

LEPIDOCYCLINA (EULEPIDINA) DILATATA (Michelotti).

(Plate XII., Figs. 1, 2.)

Orbitoides dilatata Michelotti, 1861, p. 17, pl. i., f. 1, 2.

Orbitoides (Lepidocyclina) dilatata Mich., Gumbel, 1870, p. 681, pl. iv., f. 45a,b, 46, 47.

Lepidocyclina dilatata (Mich), A. Silvestri, 1910, p. 139, pl. xxv., f. 9a-c; pl. i., f. 4-10. Chapman, 1926, p. 93, pl. xviii., f. 4a,b; pl. xx., f. 1.

Observations.—The present examples average about 12 mm. in diameter, and are thus more than twice as large as the New Zealand specimens from North Auckland and Titirangi.

The distribution of *L. dilatata* in East Borneo, as recently given by Van der Vlerk (1925, Table), shows this species to be there characteristic of the Oligocene (that is, "Post-Eocene Naintoepe Beds") above which succeed the *Lepidocyclina tournoueri* beds (the "Poeloe-Balang Beds").

Occurrence.—Frequent.

Genus **Miogypsina** Sacco.

MIOGYPSINA cf. **IRREGULARIS** (Michelotti).

Nummulites irregularis Michelotti, 1841, p. 296, pl. iii., f. 5.

Miogypsina irregularis (Mich.), Schlumberger, 1900, p. 328, pl. ii., f. 1-7, 9, 10; pl. iii., f. 17. Chapman, 1926, p. 93, pl. xviii., f. 5a,b; pl. xx., f. 3, 4.

Observations.—Fragmentary specimens of this or an allied form occur in the washings. It may belong to an earlier type of foraminifera, or if referable to the above, shows, as in New Zealand, a commingling of Oligocene and Miocene forms.

Occurrence.—Frequent.

Phylum **MOLLUSCOIDEA**.

Class **POLYZOA**.

Order **CYCLOSTOMATA**.

Fam. **CRISIIDAE**.

Genus **Crisia** Lamouroux.

CRISIA GRACILIS MacGillivray.

Crisia gracilis MacGillivray, 1895, p. 118, pl. xvi., f. 5.

Observations.—The original and only locality for this species is

the Oligocene beds at Clifton Bank, Muddy Creek, Western Victoria.

Occurrence.—Very rare.

Phylum MOLLUSCA.

Class PELECYPODA.

Fam. DIMYIDAE.

Genus *Dimya* Roualt.

DIMYA DISSIMILIS Tate.

Dimya dissimilis Tate, 1886, p. 100, pl. iii., f. 9a-c. Harris, 1897, p. 306.

Observations.—A right valve of a subcircular form, with fine radial and undulate concentric ornament, occurs here. The inside of the valve is quite smooth, and thus precludes it from a comparison with *D. sigillata* Tate. This species has an extensive geological range within south-eastern Australia, from the Oligocene to Lower Pliocene.

Occurrence.—One valve.

Phylum ARTHROPODA.

Super Order OSTRACODA.

Fam. CYPRIDAE.

Genus *Aglaia* G. S. Brady.

AGLAIA CLAVATA G. S. Brady.

Aglaia clavata G. S. Brady, 1880, p. 34, pl. vi., f. 4a-d.

Observations.—This is the first time that *A. clavata* has occurred fossil. It only shows, in common with many other Australian recent species of ostracoda, that the living fauna was established in southern waters in early Tertiary times.

Occurrence.—Very rare.

Fam. CYTHERIDAE.

Genus *Cythere* O. F. Müller.

CYTHERE LACTEA G. S. Brady.

Cythere lactea G. S. Brady, 1865, p. 377, pl. lx., f. 3a-c. Idem, 1880, p. 91, pl. xxii., f. 1a-d. Chapman, 1914, p. 36, pl. vii., f. 15.

Observations.—The present examples are small but typical valves belonging to the above species. *C. lactea* occurred in the Janjukian (Miocene) of the Mallee Bores, and it persists to the present day round the Australian coast.

Occurrence.—Two opposite valves.

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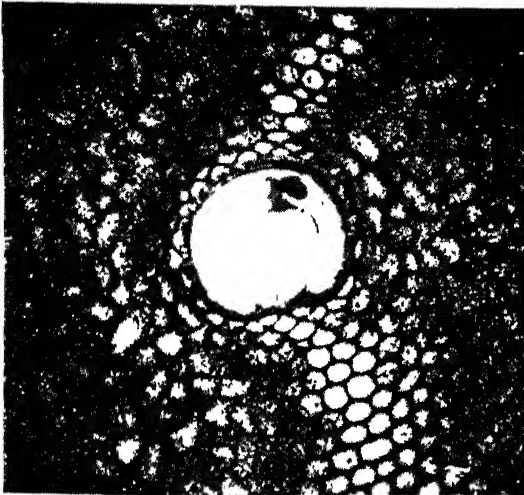
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EXPLANATION OF PLATES.

- Fig. 1.—Photograph of naturally fractured limestone from Exmouth Gulf, showing abundance of tests of *Cyclocypeus* and *Lepidocyclina*. Slightly reduced.
 Fig. 2.—Horizontal section through test of *Lepidocyclina dilatata* (Michelotti); showing primordial and circumambient chamber in median section. The inner chamber has a diameter of 42 micra, the outer 77 μ . $\times 28$.
 Fig. 3.—Section of the limestone, with a portion of the test of *Cyclocypeus pustulosus* (Chapm.), seen in median aspect. The chamberlets measure 27 by 13 μ . $\times 28$.
 Fig. 4.—*Bolivina spiroplectiformis*, sp. nov. Test. $\times 104$.



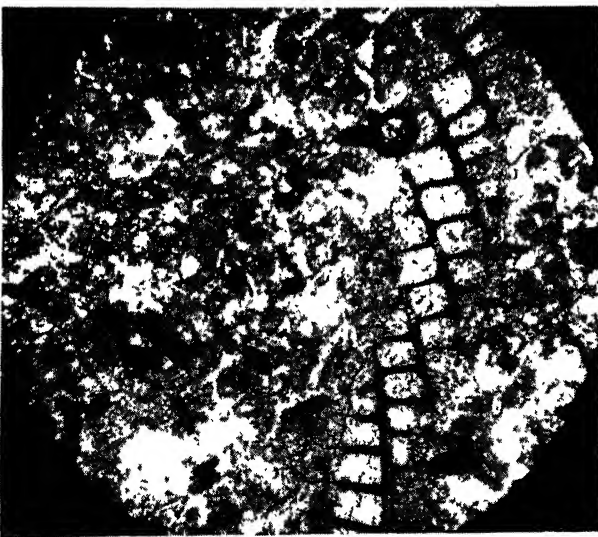
1
Nat.
Size



2
x28



4
x104



3
x 28

ART. XIII.—*The Leaf of Grewia polygama and its Tannin Content*

By ALICE M. COVERLID, B.Sc.

(Communicated by Professor A. J. Ewart.)

[Read 9th December, 1926.]

Dried leaves of *Grewia polygama*, which belongs to the Natural Order Tiliaceae, were sent down by Captain Bishop, Veterinary Surgeon at Darwin. A decoction of the leaves is considered, throughout the Northern Territory and Queensland, to be an admirable bushman's remedy for cases of diarrhoea and dysentery, and *Grewia polygama* is recorded in Bailey's "Queensland Plants" as a "valuable remedy" for dysentery.

The decoction is made by pouring boiling water on to the leaves. Decoctions made in this way in the laboratory showed that quantities of a mucilaginous material, which gathered in the form of a cloudy precipitate, were present; also, judging by colour and taste, tannins. The mucilaginous material gave a stringy precipitate with alcohol, and could thus be isolated from the decoction. It was dissolved in weak alkali, and gave a positive Fehling's reaction. The positive furfural reaction and colour with the orcinol test proved that it is a pentose. The tannin is readily soluble, even in cold water. The test with ferric acetate showed a green colour, indicating the presence of pyrocatechol tannins, but further work was sufficient to show that the solution probably contains a mixture of tannins.

Several estimations of the percentage of tannin present were made by the Lowenthal-Schroeder method, and by Proctor's modification of this method (1). This depends on the reducing power of the tannin, and as this varies for each tannin, the method cannot give an exact result, but since the amount of tannin in the leaves varies according to the time of the year, and also according to the age of the leaves, an average result is all that can be hoped for.

First the dried leaves were ground up finely in a mincer, a large amount being ground at one time, so that each sample for estimation was taken from a well-mixed supply. It was noted that all the leaves in the quantity sent were mature; no young leaves or buds were present.

The moisture content of a weighed amount of the air-dried leaves (5.157 grams) was determined, and found to be 11.7%. From this, the dry-weight of each sample taken could be calculated. In the Lowenthal and Schroeder method, the use of a solution of indigo-carmin is necessary to control the oxidation of the

tannin by the permanganate, otherwise the oxidation is too slow, and a definite end-point is not reached. The acid solution required by the permanganate oxidation method is supplied by the sulphuric acid in which the indigo-carmin is dissolved.

Since the infusion contains other oxidisable matters besides tannins, it is necessary to separate these and titrate a second time, in order to ascertain the volume of permanganate actually required by the tannin present. This is done by digestion with hide-powder. As the permanganate has to be standardised also, and the amount of permanganate used up by the indigo-carmin solution alone has to be found, there are four titrations required for each estimation, each of which must be repeated more than once.

For each estimation a known weight of leaves is treated with successive quantities of boiling water, sufficient to give a litre of infusion. Preliminary titrations were done to find approximately the weight of leaves which would give an infusion containing 0.4% tannin (the strength recommended for this method).

Estimations showed that only about 4% tannin was present in the particular leaves submitted. In tea leaves, there is often more than 10% tannin present, so that if the tannin is the active principle, in the form of an astringent, as was supposed, it must be a very active form of tannin.

The presence of resorcinol in the decoction is indicated by the positive result of a test on a pine-wood shaving, using the decoction and strong hydrochloric acid. A pale mauve colour was produced: such a test as this cannot be held a proof of its presence, and another specific test for resorcinol which was tried did not give a positive result. If resorcinol is proved to be present, it must be in such minute quantities that its therapeutic value as an antiseptic would be negligible.

Only dried material was available for sectioning. To soften and expand the leaf-tissues, before proceeding to imbed the leaves for sectioning, the quicker method of boiling in water was used, since it was found to give results quite as good as the use of glycerine with long soaking.

Sections of the leaf showed a rather interesting structure. The tannin is apparently not localised in special cells of the leaf. Mucilage-canals traverse the leaf, some running in the parenchymatous tissue below the main vascular bundle, and some near the upper leaf-surface. The upper epidermal layer contains mucilage, the presence of which is brought out very well in sections stained with ruthenium red. These upper epidermal cells are unusually large, and the cuticle is quite thin. The presence of mucilage in the epidermal cells undoubtedly delays transpiration to some extent, and is probably a xerophytic adaptation, although less effective than the formation of a thick cuticle. Cannon, in his paper on the Vegetation of the more arid portions of South Africa (2), refers to this fact.

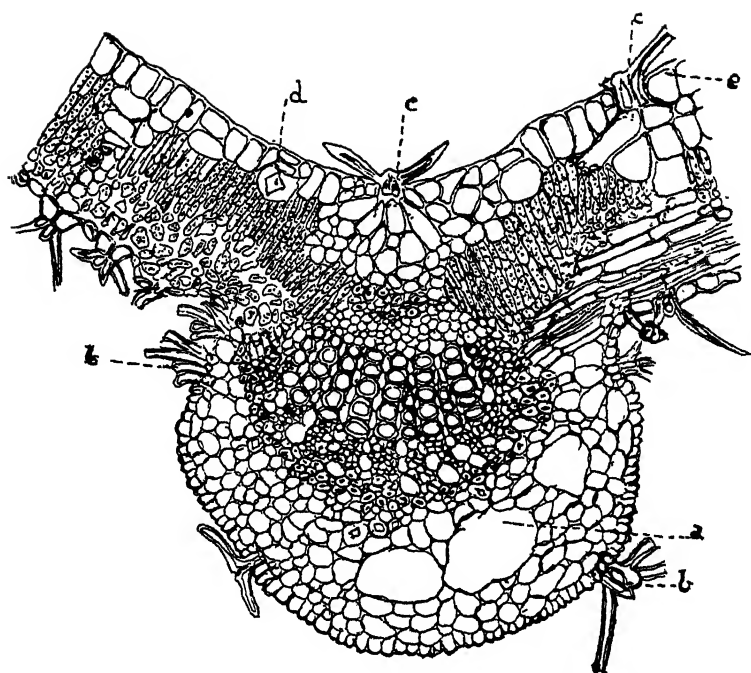


FIG. 1.—Vertical Section of leaf in region of midrib.

- (a) Mucilage canals in parenchyma below vascular strand.
- (b) Hair of lower epidermis.
- (c) Thickly cuticularized hairs of upper epidermis.
- (d) Crystal cell.
- (e) Large epidermal mucilage-cell.

At definite points, just below the upper surface of the lamina, sometimes in the upper epidermis itself, there occur large crystal cells, each containing a single rhomboidal crystal, which, when tested microchemically, proved to be calcium oxalate. A few smaller crystals occur scattered through other parts of the leaf. The large crystals always show noticeably concave faces; this would be due to their formation in a mucilaginous medium, such as is evidently present in the enlarged crystal cells.

There are multifid cuticularised hairs present on both the upper and lower epidermal surfaces, although it is only on the lower epidermis that the hairs form what could be called a covering. Even there, the protruding ribs below the leaf-trace bundles are very sparsely covered with hairs.

On the upper surface the appearance is strongly suggestive of a connection of some kind between the mucilage ducts and the hairs. The ducts appear to run up towards the upper epidermis at the points where the hairs are inserted. The hairs are even more

cuticularised than those on the lower epidermis, and it is hard to understand of what importance such a connection would be, for-

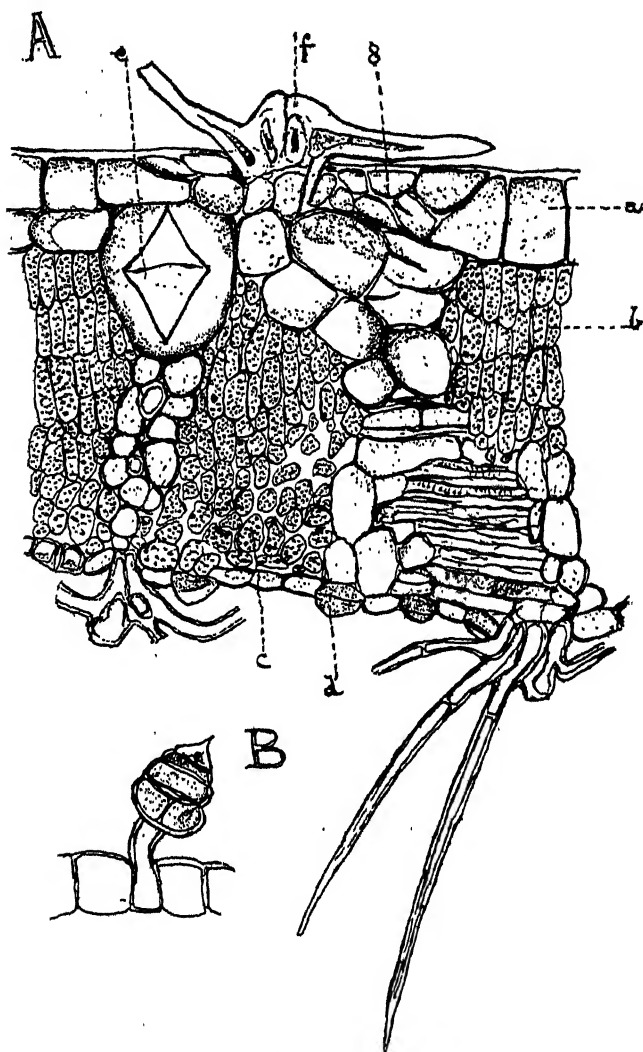


FIG. 2.—A. Vertical section through leaf. $\times 270$.

- (a) Large mucilaginous cell of normal epidermis.
 - (b) Palisade layer of mesophyll.
 - (c) Spongy mesophyll.
 - (d) Large stoma, surface view.
 - (e) Crystal of calcium oxalate in enlarged cell with mucilage.
 - (f) Hair of upper epidermis cut vertically.
 - (g) Multiple epidermis at insertion of hair.
- B. Glandular Hair. $\times 270$

the cell-walls of the hair are cuticularised right down to those cells which form, as it were, the "root" of the hair. Some indication of the same appearance of a connection has also been seen occasionally between hairs of the lower epidermis and mucilage ducts.

Other hairs, shortly stalked, and apparently glandular, occur on both surfaces of the leaf.

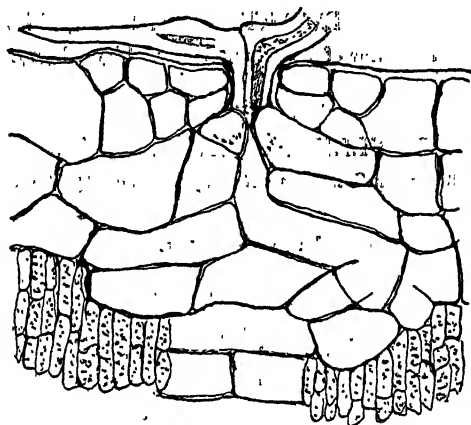


FIG. 3.—Vertical Section, through insertion of an upper epidermal hair, to show the typical multiplication of epidermal cells, and the canal-like arrangement of mucilage-containing cells curving up towards the hair. $\times 270$.

The stomata present an unusual appearance; they are large, distinctly projecting from the main epidermal level, and stain intensely with ruthenium red. They may occur in rather large and shallow stomatal pits, but are not confined to these.

A remarkable fact about the use of this plant as a medicine is that the aborigines do not know of it, and they are always credited with knowing all the plants in the North that have any important medicinal value.

This investigation has shown no basis for the belief that this decoction is of any special use in cases of dysentery as compared with specifics already known.

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2. A. CANNON. Features of the Vegetation of the More Arid Portions of Southern Africa. Published by the Carnegie Institution of Washington, Aug., 1924.

ART. XIV.—*Contributions to the Flora of Australia, No. 33.**
Additions to the Flora of the Northern Territory and
Locality Records.

By ALFRED J. EWART, D.Sc., Ph.D., F.L.S., F.R.S.
(Professor of Botany and Plant Physiology),

and

PHYLLIS H. JARRETT, B.Sc.
(Howitt Research Scholar in Botany, University of Melbourne).

[Read 9th December, 1926.]

The present paper completes the identification of the collections made by the senior author in 1924. It also contains information derived from Mr. C. E. F. Allen's collection and from the Tate Herbarium, Adelaide. In addition it has been possible to append notes on the economic value of several species from information derived from Mr. Allen of Darwin, and from Sergeant Stott of Alice Springs. A small collection of plants from the Barrow Creek area was also received from Miss Crook of Wycliffe Well.

In the Northern Territory we find the most extreme degree of specialisation of the Australian flora. Over a large portion of the Territory, conditions are very arid, and the consequent xerophytic adaptations to these conditions are highly complex. From this point of view the origin of the flora and its evolutionary history is a subject of special interest; and perhaps ultimately it may be possible to apply such conceptions as Willis's Age and Area hypothesis to this problem. In the Northern Territory we have a large area in which the struggle for existence is severe, the environment is fairly uniform, and barriers to migration are almost absent—conditions peculiarly favourable for confirming the conclusions derived from a hypothesis of this kind.

CONIFERAE.

Callitris robusta R.Br.

Buxstone and MacDonnell Ranges, C. E. F. Allen (No. 374),
July, 1922.

GRAMINEAE.

Rottboellia exaltata Linn.

Stapleton, C. E. F. Allen (No. 717), December, 1922.

*No. 32 in *Proc. Roy. Soc. Vic.*, n.s., xxxix. (1) p. 1., 1926.

Themeda triandra Forst.

Roper River Flats, C. E. F. Allen (No. 733), May, 1924.

Panicum sanguinale Linn.

Arltunga gold fields, C. E. F. Allen (No. 614), July, 1922.

Eriachne stipacea F.v.M.

Low coast lands, Darwin, C. E. F. Allen (No. 518), March, 1922.

Pappophorum nigrum R.Br.

Alice Springs, C. E. F. Allen (No. 567), July, 1922. Mr.

Allen states that this plant is a good fodder.

Eragrostis Dielsii Pilger (= *E. falcata* Benth.).

Near Darwin, C. E. F. Allen (No. 441), January, 1920.

CYPERACEAE.

Cyperus concinnus R.Br.

Near Darwin, C. E. F. Allen (No. 519), March, 1922.

C. Iria Linn.

Barrow Creek, Miss Crook, July, 1926.

Schoenus sparteus R.Br.

Near Darwin, C. E. F. Allen (No. 520), March, 1922.

CASUARINACEAE.

Casuarina Decaisneana F.v.M.

MacDonnell Ranges, G. F. Hill, May, 1911.

ULMACEAE.

Trema aspera Blume.

Simpson's Gap, Mrs. Dutton, July, 1924.

T. cannabina Lour.

MacDonnell Ranges, F. W. Schwarz, 1889; Alice Springs, R. Tate, 1894.

PROTEACEAE.

Grevillea agrifolia A. Cunn.

Near MacDonnell Ranges, R. Tate, 1889; Attack Creek, E. C. S., May, 1891.

G. angulata R.Br.

Hamilton Down Station, near Alice Springs, Sergeant Stott, September, 1926.

This species is very plentiful throughout Central Australia and is recorded as a good fodder, being an excellent stand-by during drought.

G. pterospermum F.v.M.

Bagot's Creek, Ralph Tate, 1894.

G. refracta R.Br.

South Northern Territory, E.C.S., May, 1891; (also Fitzroy River, N.W. Australia, Calvert Expedition, 1897).

G. stenobotrya F.v.M.

Chamber's Pillar, MacDonnell Ranges, Ralph Tate, 1894.

G. stricta R.Br.

Horse-shoe Bend, Mrs. Osborne, 1924.

Hakea intermedia Ewart and Davies.

MacDonnell Ranges, Ralph Tate, 1894 (labelled *H. lorea* in Tate Herbarium).

Banksia dentata R.Br.

Wet land eight miles from Darwin, C. E. F. Allen (No. 549), March, 1922.

LORANTHACEAE.

Loranthus sanguineus F.v.M.

Stapleton, C. E. F. Allen, (No. 547), December, 1922.

POLYGONACEAE.

Emex spinosa Campd. Rum.

Alice Springs, Sergeant Stott, April, 1926.

This plant has not previously been recorded from the Northern Territory.

CHENOPODIACEAE.

Hemichroa diandra, R.Br.

Taylor Creek, A.J.E., June, 1924.

Rhagodia spinescens R.Br.

MacDonnell Ranges, Ralph Tate, 1889.

Atriplex nummularia Lindl.

Alice Springs, Sergeant Stott, September, 1926.

This is an excellent fattening fodder for sheep and cattle.

Bassia divaricata F.v.M.

Ryan's Well, C. E. F. Allen (No. 575), July, 1922.

This species has not previously been recorded from the Northern Territory.

Kochia aphylla R.Br.

Alice Springs, C. E. F. Allen (No. 621), July, 1922, and Sergeant Stott, September, 1926.

This species which is an excellent cattle fodder is plentiful in various parts of Central Australia.

R. triptera Benth.

Ryan's Well, C. E. F. Allen (No. 576), July, 1922; Wycliffe Well, C. E. F. Allen (No. 644), July, 1922.

R. villosa Lindl.

Alice Springs, Sergeant Stott, September, 1926. A good fodder.

Enchylaena tomentosa R.Br.

Alice Springs, Ralph Tate, 1894.

Salsola Kali Linn., var. *strobilifera*.

Barrow Creek, Miss Creek, July, 1926.

AMARANTACEAE.

Trichinium macrocephalum R.Br.

Alice Springs, Sergeant Stott, September, 1926.

Grows prolifically on stony ridges. A good stock fodder procurable throughout Central Australia.

T. obovatum Gaud. var. *grandiflorum* Benth.

Burt Plain and Mount Gillen, Alice Springs, Sergeant Stott, September, 1926.

A good fodder common in Central Australia.

Gomphrena canescens, R.Br.

Emily and Burt Plains, Alice Springs, Sergeant Stott, September, 1926.

AIZOACEAE.

Mollugo cerviana Ser.

Barrow Creek, Miss Crook, July, 1926.

Glinus (*Mollugo*) (*Aizoaceae*).

Wycliffea, Ewart and Petrie, Contrib. Flora of Austr. No. 31, Proc. Roy. Soc. Vic., n.s., xxxviii., 1926 (*Caryophyllaceae*).

Glinus spergula Linn. (= *Wycliffea obovata* Ewart and Petrie).

G. spergula Linn. var. *rotundifolia* n. var. (= *Wycliffea rotundifolia* Ewart and Petrie).

The two species of *Wycliffea* are merely highly cleistogamic forms of *Glinus spergula* adapted to arid conditions. The boundary between the *Aizoaceae* and *Caryophyllaceae* is not well defined, and it is possible that this section of the *Aizoaceae* is more closely allied to the *Caryophyllaceae* than to the order in which it is placed.

LEGUMINOSAE.

Caesalpineae.

Cassia leptoclada Benth.

Kelly's Well, C. E. F. Allen (No. 609), July, 1922.

Papilionaceae.

Mirbelia oxyclada F.v.M.

Tablelands south of Renner Springs, C. E. F. Allen (No. 674), July, 1922.

M. daviesioides Benth (= *M. aphylla* F.v.M.).

Bagot's Creek Gorge and Gill's Range, Ralph Tate, 1894, labelled *M. oxyclada*.

Crotalaria incana Linn.

In the sandy country near the coast, Darwin, C. E. F. Allen (No. 413); October, 1921.

This species has not previously been recorded for Northern Territory.

C. linifolia Linn.

In the sandy country south of Darwin, C. E. F. Allen (No. 632), July, 1922.

C. trifoliatrum Willd. var. *angustifolium*.

No. 2 Bore, Northern Wells, C. E. F. Allen (No. 633), August, 1922.

Wycliffe to Taylor, A.J.E., June, 1924.

This variety has not previously been recorded for Northern Territory.

Tephrosia sphaerospora F.v.M.

Ooramina, Central Australia, Ralph Tate, 1894.

T. eriocarpa Benth.

On the rocky ridges east of Taylor Range, A.J.E., June, 1924.

Swainsona Burkei F.v.M.

MacDonnell Ranges, C. E. F. Allen (No. 612), August, 1922.

Alice Springs, Sergeant Stott, September, 1926.

This species is plentiful throughout Central Australia and is an excellent fodder plant.

S. phacoides Benth.

Alice Springs, Sergeant Stott, September, 1926.

This species is plentiful throughout Central Australia and has a high fodder value.

S. microphylla A. Gray.

Wycliffe Creek, C. E. F. Allen (No. 596), July, 1922.

This is the first definite locality record for this species.

Glycine falcata Benth.

Alice Springs and Stuart, A.J.E., June, 1924.

ZYGOPHYLLACEAE.

Tribulus angustifolius Benth.

Barrow Creek, Miss Crook, July, 1926.

EUPHORBIACEAE.

Phyllanthus maderospatanus F.v.M.

Taylor Range, A.J.E., June, 1924.

This plant is greedily eaten by stock.

Petalostigma quadriloculare F.v.M. var. *nigrum* Ewart and Davies.

Wycliffe, A.J.E., June, 1924.

This plant is locally known as Quinine Bush on account of its very bitter fruits.

TILIACEAE.

Grewia polygama Roxb.

Near Darwin, Captain Bishop, April, 1926.

MALVACEAE.

Sida rhombifolia Linn.

Stuart to Alice Springs, A.J.E., June, 1924.

Hibiscus cannabinus Linn.

Barrow Creek, Miss Crook, July, 1926.

BIXINEAE.

Cochlospermum Fraseri Planch.

Macadam Ranges, Mt. Victoria, Fitzmaurice River, Dr. Basedow, 1922.

This plant has not previously been recorded for Northern Territory.

VIOLACEAE.

Ionidium suffruticosum Ging. (= *Hybanthus enneaspermus* F.v.M.)

Barrow Creek, Miss Crook, July, 1926.

MYRTACEAE.

Eugenia Holteana F.v.M.

Near Darwin, C. E. F. Allen, (No. 540), June, 1922.

This is the first definite locality record for this species.

E. Jambolana Lam.

Near Darwin, C. E. F. Allen, (No. 403), August, 1919.

This species has not previously been recorded for Northern Territory.

Eucalyptus grandifolia R.Br.

Stapleton, C. E. F. Allen (No. 461), December, 1922.

CONVOLVULACEAE.

Cuscuta epithymum Murr. Syst.

Alice Springs, Sergeant Stott, April, 1926.

BORAGINACEAE.

Heliotropium paniculatum R.Br.

Wycliffe, A.J.E., June, 1924.

Trichodesma zeylanicum R.Br.

Barrow Creek, Miss Crook, July, 1926.

LABIATAE.

Mentha australis, R.Br.

Neiles' Creek, Oodnadatta, S. Australia, A.J.E., April, 1924.

This species has not been recorded for the Northern Territory, but approaches the boundary.

SOLANACEAE.

- Solanum echinatum* R.Br.
Alice Springs, C. E. F. Allen (No. 627), July, 1922.
- S. nigrum* Linn.
Roper River, C. E. F. Allen (No. 738), May, 1924.
- S. quadriloculatum* F.v.M.
Near Alice Springs, C. E. F. Allen (No. 680), August, 1922.

RUBIACEAE.

- Dentella repens* Forst.
Barrow Creek, Miss Crook, August, 1926.
- Gardenia edulis* F.v.M.
Near Darwin, C. E. F. Allen (No. 406), August, 1919.

CUCURBITACEAE.

- Momordica myriocarpus* Linn.
Taylor's Flat, A.J.E., June, 1924.
- Melothria maderospatanus* Cogn.
Barrow Creek, Miss Crook, July, 1926.

CAMPANULACEAE.

- Lobelia dioica* R.Br.
Near running water, Banka Banka Station, South of Powell's Creek, C. E. F. Allen, (No. 663), August, 1922.
- L. stenophylla* Benth.
On lowlands near Darwin, C. E. F. Allen (No. 521), March, 1922.
- Isotoma petraea* F.v.M.
On wet country near Darwin, C. E. F. Allen (No. 524), March, 1922.

GOODENIACEAE.

- Goodenia Haverlandi* Maiden and Betcher.
Between Wycliffe and Taylor, A.J.E., June, 1924.
This species has not been previously recorded for Northern Territory.
- G. heterochila* F.v.M.
Barrow Creek, Miss Crook, July, 1926.
- G. mollissima* F.v.M.
Barrow Creek, Miss Crook, July, 1926.
- G. Strangfordii* F.v.M.
Barrow Creek, Miss Crook, July, 1926.
- Scaevola microcarpa* Cav.
Barrow Creek, Miss Crook, July, 1926.
This species has not previously been recorded for Northern Territory.

COMPOSITAE.

Helipterum incanum D.C.

Alice Springs, Sergeant Stott, September, 1926.

This is the first definite locality recorded for this species though it is common throughout Central Australia; it is a good fodder plant.

[Read 9th December, 1926.]

$$2\omega \sin \phi . G = \frac{1}{\rho} \frac{dp}{dn} \quad . \quad . \quad . \quad . \quad A.$$

$\frac{dp}{dn}$ is the pressure change per unit distance normal to the isobars.

The investigations of this paper are confined to geostrophic winds of less than 13 metres per second. Since two-thirds of the values lie between 7.4 and 10.5 metres per second the conditions are fairly homogeneous. For higher velocities the conditions are more complex and their investigation has not been completed. Means of the actual and geostrophic winds are exhibited in Table I. and Figure 1. This paper is concerned with the explanation of the average actual wind distribution from near the surface up to about 1000 metres in terms of the eddy diffusivity and geostrophic wind.

The motion at any height z is indicated in Figure 2, where OX is parallel to the surface geostrophic wind and OY is in the direction of decreasing pressure. The angle GOE is the angle between the actual wind and the geostrophic wind. The component wind velocities u and v are along OX , OY respectively.

Brunt simplified the treatment of the equations by using a vectorial notation, representing the horizontal velocity by W where $W = u + iv$.

Then regarding K and G as constants the solution, after neglecting that part which leads to an indefinite increase of velocity with height, is given by him (2) as

$$W - G = C e^{-(1+i)Bz + i\gamma} \quad D$$

where C and γ are real constants to be determined from boundary conditions and $B^2 = \omega \sin \phi / K$.

Brunt, following Taylor and others, assumes that at the ground the up-gradient of velocity is in the direction of motion. In theory this condition is applied at the surface, but in practice $z=0$ is taken to be some indefinite height "near the surface." This is equivalent to applying at a height near the surface the determining condition that there the up-gradient of velocity is in the direction of motion.

Three objections may be raised to these conditions:—

1. They are based upon an assumption which certainly does not always hold. Richardson (3) for instance gives a number of examples showing that the stress on the ground has a direction differing from the wind near the surface.
2. The height at which they are applied is too indefinite. This objection is important since the velocity changes rapidly near the surface.
3. It is now known that near the surface the eddy diffusivity decreases rapidly in disagreement with the assumption used in solving the equations.

An improvement would therefore be made if a condition for determining the constants could be found which was applicable at a definite height and required no additional assumption regarding frictional forces. It would be a further gain if this height were such that the condition as to constancy of eddy diffusivity was approximately fulfilled. Equation D leads to the following result:—

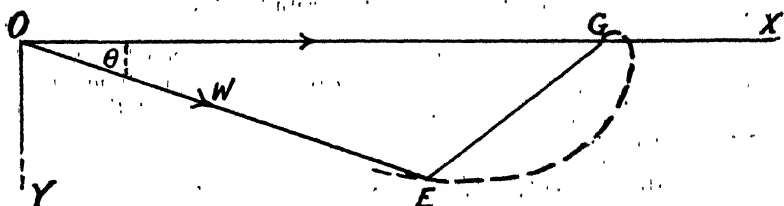


FIG. 2.

Referring to the explanatory diagram, Fig. 2, OG represents the geostrophic velocity along OX, and OE the vector velocity W. It has been pointed out that as W varies with height the solution indicates that the end of the vector GE traces out an equiangular spiral. Now if at any height z_1 , the vector representing the wind is a tangent to that spiral, then at that height the direction of shear is in the direction of motion. The usual conditions will then be applicable at z_1 , no additional assumption being needed. Since Brunt used the same conditions for different reasons as applying at the surface, his results can be used by substituting $z-z_1$ for his z . Hence the final solution is (2)—

$$W - G = \sqrt{2G} \sin \theta_1 e^{-B(z-z_1) + i(\theta_1 + \frac{3}{2}\pi - B(z-z_1))} \quad \dots \quad E$$

and at z_1 , the well-known relation holds

$$\sqrt{u^2 + v^2} = V = G(\cos \theta_1 - \sin \theta_1) \quad \dots \quad F$$

θ_1 is the deviation of the wind from the geostrophic direction at the height z_1 .

The value of K may be obtained from the wind data by the use of the formula

$$B^2 = \frac{\left(\frac{du}{dz}\right)^2 + \left(\frac{dv}{dz}\right)^2}{2 \{ (G - V)^2 + 2G(V - u) \}} \quad \dots \quad G$$

This follows immediately from equation D, and the constancy of G and K is therefore assumed. For the intervals 50-150 metres, and 150-300 metres, the magnitudes of K were found to be $3.1.10^4$ and $3.7.10^4$ respectively. Beyond that height reliance cannot be placed on the results as the quantities involved become too small. With the same assumption that G and K are constant, the latter can also be obtained from the relations given by Taylor (4)—

$$\begin{aligned} BH_d &= \frac{3}{2}\pi + \theta_1 \quad \dots \quad H \\ e^{-BH_v} &= \frac{(1 + \tan \theta_1) \cos BH_v - (1 - \tan \theta_1) \sin BH_v}{\tan \theta_1} \quad \dots \quad I \end{aligned}$$

where

H_d = height at which the geostrophic direction is reached.

H_v = height at which the geostrophic velocity is reached.

For the winds dealt with here $H_d = 825m$, $H_v = 340m$, $\theta_1 = 18.6^\circ$.

The resulting values of K are $4.8.10^4$ and $4.2.10^4$ respectively. The eddy diffusivity thus appears to be approximately constant over the range of height considered and a good average value is $4.0.10^4$.

Theoretically, since θ_1 is the maximum value of θ , the deviation from the geostrophic direction, it should be possible to determine θ_1 and consequently z_1 , directly from the observations. Since θ_1 varies very slowly with height near z_1 , and owing to various sources of irregularity, the results so obtained would be rather indefinite. The approximate value of θ_1 from the observations is 18.6° . Now it can be shown that

$$\text{Angle OGE (Fig. 2)} = B(z-z_1) - \theta_1 + \pi/4$$

Hence knowing θ_1 , z_1 can be computed from the observations at various heights. Using the above approximate value of θ_1 , we obtain the following results:—

$z = 50$	150	300	450	750 metres.
$z_1 = 54$	40	15	34	80 metres.

These give a mean value of 45 m. for z_1 .

The value 50 m. will be adopted for z_1 . It is near that determined above from the 50 m. observations for which the probable error is least, and also near the mean value. Furthermore it is the height at which θ_1 is a maximum and the equation F is fulfilled by the observations at that height. At 50 m. above the ground the effect of the decreasing eddy diffusivity will be less than at the lower heights usually taken as "near the surface."

We now have for the theoretical distribution the constants—

$$\theta_1 = 18.6^\circ, \quad z_1 = 50 \text{ m.}, \quad G = 8.9 \text{ m/s and } K = 4.0.10^4.$$

The values of V and θ derived from equation E are shown for stated heights in Table I. and graphed in Fig. 1 along with the actual winds, with which they are in remarkable agreement. Most of the calculations in this paper were made with a M.O. Pilot Balloon Slide Rule.

In conclusion I wish to thank Mr. H. A. Hunt, Commonwealth Meteorologist, for facilities for writing this paper.

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ART. XVI.—*The Tasmanian Tektite—Darwin Glass.*

By SIR T. W. EDGEWORTH DAVID, D.Sc., K.B.E., F.R.S.,
H. S. SUMMERS, D.Sc., and G. A. AMPT, B.Sc.

(With Plate XIII.)

[Read 9th December, 1926.]

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 - c. Fulguritic.
 - i. From fusion of siliceous sands at surface of ground.
 - ii. From fusion of dust clouds in a thunderstorm.
 - d. Meteoritic.
- X. SUMMARY AND CONCLUSIONS.

I.—Introduction.

Considerable interest has been excited for many years past through the scientific world in the small bodies known as Tektites, the origin of which is still a mystery. Quite an extensive literature already exists dealing with the Moldavites of the Moldau River area, the Billitonites of the Netherlands East Indies, the Australites of the Commonwealth, and the Schonite of Scandinavia.

The remarkable variety of tektite known as Darwin Glass, has, as yet, hardly attracted the attention which its importance seems to the writers to deserve. Darwin Glass, so far, has been received only from the area of the Jukes-Darwin mining field. This area is situated to the east of Macquarie Harbour on the West Coast of Tasmania, and commences at a point about 12 miles south of the Mount Lyell Mine. A full account of its

original discovery through Mr. V. Bruscoe, M. Donohue and Mr. Hartwell Conder, M.A., Assoc.R.S.M., is given in the original paper describing this glass by Professor Franz Suess (1). In it he quotes from a detailed letter describing the occurrence by Loftus Hills and Twelvetrees. This is reviewed in still more detail by Dr. Loftus Hills (2).

One of the writers, Professor Sir Edgeworth David, recently was so much impressed with the importance of this discovery that he made a special visit to the principal locality and had the good fortune to be accompanied by Mr. Hartwell Conder, the engineer who was chiefly responsible for bringing the matter before the scientific world. He desires specially to acknowledge the invaluable help and advice of Mr. Conder, and the generous assistance given him by Mr. R. M. Murray, General Manager of the Mount Lyell Mine, Mr. H. J. Clarke, Engineer of Works, Mr. D. Lumsden, Secretary of the Mount Lyell Company, Sir John Grice, Chairman of Directors of the Emu Bay Railway Company, and to the Tasmanian Government for travelling facilities. Lastly he is specially indebted to Dr. Loftus Hills for details in regard to mode of occurrence, etc., of the Darwin Glass, suggested by the latter's extensive personal local knowledge.

II.—Bibliography.

Reference has already been given to the two and only papers hitherto dealing with the subject of Darwin Glass.

In Professor Suess's paper the Darwin Glass, as it was originally named by the late W. H. Twelvetrees, former Government Geologist of Tasmania, is named Queenstownite—Queenstown being the largest settlement in its vicinity. Professor Suess would have named it Tasmanite, but for the fact that the term is already bespoken for the spore-bearing oil shale of the Latrobe area in Tasmania. The term Darwinite is also already appropriated to a mineral. It is proposed in this paper to adhere to Mr. Twelvetrees' original name of Darwin Glass. An objection to Queenstownite is that there are at least four towns within the British Empire of that name. Professor Suess has given such an excellent description of the Darwin Glass, together with chemical analyses, that we have little to add to his classic paper. Nevertheless some new observations have come to light which seem worth recording. Dr. Loftus Hills has well summarised all that was known about Darwin Glass up to the year 1915. His account should be read in conjunction with his work on the Jukes-Darwin mining field, forming Bulletin No. 16 of the Geological Survey of Tasmania.

III.—Mode of Occurrence.

The area where Darwin Glass seems to be most abundant is at the Ten Mile on the spur of Mount Darwin, trending down to the railway cutting at ten miles up from Kelly's Basin on Macquarie



Harbour northwards, on the North Lyell Railway. The Darwin Glass is abundantly found in the cutting itself, and up the hill slope to a height of about 1300 feet above sea level. Strange to say, above the level of 1300 feet, the Darwin Glass has nowhere been met with, either on Mounts Darwin, Jukes, or Sorell. An ingenious explanation of the restriction in altitude of the occurrence of the Darwin Glass has been offered by Mr. Hartwell Conder. It is well known that this West Coast of Tasmania was heavily glaciated in Pleistocene time, and Mounts Darwin, Jukes, Sorell, and adjacent areas, show abundant evidence of the snow fields and glaciers having come down to within about 1000 feet of sea level. Indeed, during the maximum glaciation in early Pleistocene time, the glaciers in the Henty area came to within 200 feet or less of sea level. Conder assumes that, on the theory that the Darwin Glass was of meteoritic origin, as will appear most probable in the sequel, the hailstorm of small meteorites fell uniformly over the whole area of Mount Darwin for some twelve miles north of the Ten Mile, about ten miles east of the railway line, and four miles west, on the western slopes of Mount Sorell, and at Flanagan's Flat, west of Mount Darwin. In the case, however, of portion of this area which may have still been capped with ice and *névé*, the meteorites would become lodged in the ice, and would be gradually transported by it towards the ice-margin, which at that particular time Conder argues would, on this hypothesis, be about at the top limit at which Darwin Glass is now found, namely 1300 feet above sea level.

If this view is correct, later investigation should show that the top limit of occurrence of the Darwin Glass on the western side of Mounts Darwin and Sorell is probably a little lower than that on the eastern, as the fall of the ice was chiefly westwards. This is an interesting point for detailed future investigation. We verified the statement that the Darwin Glass did not occur above the 1300 feet contour on Mount Darwin, and Conder, as well as Dr. Loftus Hills, is convinced that the glass is really absent from the higher levels. For example Donohue was much engaged in prospecting the higher levels of Darwin in search of gold, and although he was constantly on the look-out for Darwin Glass, with which he was particularly familiar, he never discovered a single specimen at the higher altitudes. At the Ten Mile the Darwin Glass occurs mostly immediately under a superficial covering of peat, which mostly forms the surface of this part of the hill slope. The peat is from 9 inches to about 18 inches in thickness. Immediately under the peat is fine rock rubble, from an eighth of an inch up to over an inch in diameter, the layer being from two to four inches in thickness, formed of pinkish sandstone or quartzite. This belongs to the West Coast Conglomerate Series of Silurian age. The Darwin Glass does not occur in the peat, which is of post-glacial origin, but only in the top two or three inches of rock rubble. Underneath the rubble is a foot or so of very fine pinkish grey sand. In places this sand thins out and

even the rock rubble also, in which case the Darwin Glass is found resting on a surface of pink quartzite. In places the covering of peat has been removed by erosion, so that the Darwin Glass is exposed at the surface. It can most easily be collected from the beds of small rills coming down the mountain side, and particularly along the line of partly washed out track going up from the Ten Mile to Mount Darwin. The fragments appear to be present at the rate of from one quarter to one half ounce per square foot of the rock rubble. If this proportion is maintained even approximately over the greater part of the area within which the Darwin Glass has been found, it is evident that in the aggregate this material would amount to probably several hundreds of tons.

A further test of Conder's theory would be the probable local enrichment in Darwin Glass near to, and just below, the assumed contours of the old ice cap, for this zone would have received the dumpings from the large area of Mount Darwin between the 1300 foot level and its summit, 3340 feet above sea level. Near Crotty, about five miles north of the Ten Mile, i.e., fifteen miles north of Kelly's Basin, the Darwin Glass is found reposing on a surface of Silurian limestone. This fact weakens the argument that the glass is of fulguritic origin, for obviously the fusion of the limestone would not produce a glass of a chemical composition like that of the Darwin Glass, which has from $88\frac{1}{2}\%$ to nearly 90% silica. In the letter by Twelvetrees to Professor Suess, the former states that "they (the mysterious pieces) have been found on the east side of Mount Darwin and at a third locality to the south of it, one and a half miles inland from Macquarie Harbour. At the last-mentioned place they were found in gravel under the grass." Possibly Twelvetrees is here referring to the occurrence three miles west of Mount Sorell, but this is nearly six miles inland from the eastern shore of Macquarie Harbour. Obviously much yet remains to be done in the way of delineating correctly the limits horizontally and vertically of the Darwin Glass, and particularly the relations of its occurrence to the gravel sheets between Strahan and Kelly's Basin, if the deposit extends as far westwards as this.

There can be little doubt but that these gravel traces are outwash apron gravels from some of the Pleistocene ice sheets. So far no traces of Darwin Glass have been met with in the oldest and earliest Pleistocene morainic deposits.

IV.—Form and Surface.

The larger fragments are rarely found in an absolutely unbroken condition. If, as supposed before, they are of meteoritic origin, and the fall dates back to Pleistocene time, they must have been subjected to frost weathering, as well as water erosion, and these two factors would certainly have largely contributed to splintering the glass. Occasionally, however, one finds a perfectly

unbroken specimen, particularly among the smaller examples. These latter are frequently of the tear-drop type. Between their two extremities these drops are generally curved. In the longer ones a small shelf or flange is developed on the concave side of this curve. Stalactitic forms often showing a spiral twist, are very common. These have a longitudinally striated appearance, something like that of pulled out and twisted toffee, owing to the considerable elongation of the gas pores parallel to the principal axis of the stalactite. Some of these types show a spiral twist of over 90° . Frequently such stalactites are bent irregularly. Occasionally one sees one of these types formed of greenish-brown glass with a droplet of clear translucent green glass firmly adhering to it. In many cases groups of small drops are closely aggregated together in many forms. They were apparently extruded, probably by gas pressure, from the molten interior of a larger fragment. More rarely the fragments are disc-shaped slightly thinned towards the centre, the disc being flattened so as to resemble a very small biscuit. More rarely still fragments are met with approaching in shape a somewhat flattened sphere. Only in some cases among the many hundreds of specimens collected has one been found (in this case by our party last April) showing a definite, though only slightly developed, rim, analogous to the rim so characteristic of Australites. This specimen is figured, Plate XIII., Fig. 1.

V.—Physical Characteristics.

(a) *Specific Gravity.*

The specific gravity of the Darwin Glass is recorded by Loftus Hills (2) as ranging from 1.874 to 2.180, the variation being due to the number of vesicles present. One of us, G. A. Ampt, has made a careful determination of the specific gravity of the powder used in an analysis and records it as 2.296 at 14.2°C . Suess (1) also records two determinations by E. Ludwig of the specimens analysed by him. These are given as 2.2921 and 2.2845 with water at $4^\circ\text{C}=1.0$. The specific gravity varies very definitely with the silica percentage, as can be seen by the following table:—

		SiO ₂		Sp. Gr.		Analyst.
No. 1	-	86.34	-	2.296	-	Ampt
No. 2	-	88.764	-	2.2921	-	Ludwig
No. 3	-	89.813	-	2.2845	-	Ludwig
Average	-	88.30	-	2.2909	-	—

(b) *Hardness.*

Loftus Hills records the hardness as being 7 on Mohs' Scale. In many cases the determination of hardness is impossible as the

material is too brittle owing to the number of vesicles. The more solid specimens tested were just scratched with difficulty by quartz, so that the hardness of these was slightly below 7.

(c) *Colour, Lustre and Transparency.*

The colour of the Darwin Glass varies considerably. Some forms are dark smoky green to almost black and only translucent in very thin fragments. Others are greyish green, fairly free from vesicles and translucent in fairly thick fragments. Occasional pieces are almost white in colour and somewhat resemble pumice owing to the extremely vesicular nature of the material. Other colours observed were grey, olivine green and yellowish green.

In thin sections all the glasses are quite transparent, but as noted above the dark coloured forms and also the whitish forms are practically opaque in thick fragments, and only translucent in thinner fragments.

The lustre of the specimens on the weathered surfaces is dull, but ranging from vitreous to dull on freshly broken surfaces. Polished surfaces show a high vitreous lustre.

(d) *Microscopic Structure.*

All the thin sections examined showed that the material consisted of light greyish to greenish transparent glass. Some specimens showed a number of minute black specks. Flow lines were present in some specimens and absent in others. The denser forms showed a moderate number of vesicles, most of which were approximately circular. Occasional vesicles drawn out parallel to the flow lines were observed. The whitish forms when sectioned were found to be quite glassy with very numerous vesicles. In polarized light no definite trace of devitrification was found.

(e) *Refractive Index.*

The refractive index of two specimens was determined by a Herbert Smith refractometer, using sodium light, the results being:—

No. 1.—1.486.

No. 2.—1.497.

In addition the specific refractivity (3) of the three specimens analysed of which the specific gravity was determined was calculated from the specific refractivity of the minerals in the norm, and from this the refractive index, with the following results:—

K (Specific Refractivity)			Density		Ref. Index.	
No. 1	-	0.2065	-	2.295	-	1.474
No. 2	-	0.2088	-	2.2921	-	1.479
No. 3	-	0.2087	-	2.2845	-	1.477

(f) *Radio-activity.*

One specimen was ground up and tested by Mr. J. S. Rogers, for radio-activity and a completely negative test was obtained.

(g) *Melting Point.*

The microscopic examination of the material showed that it was wholly glassy so that no definite melting point would exist. The apparatus at our disposal would not allow of even a moderately accurate determination of the temperature at which crystallization of the thoroughly fused material would commence, so that no tests have been made.

VI.—Chemical Composition.

L. Hills (2) and E. Suess (1) both record analyses by Dr. Ludwig of Darwin Glass. Two additional analyses have been made by one of us, G. A. Ampt, and the following is a description of the methods employed and precautions taken to ensure a high degree of accuracy.

The analyses were carried out on the general lines prescribed by Washington and Hillebrand with certain modifications demanded by the exigencies of the cases, or shown by past experience to possess advantages in rationale and technique.

The material submitted for analysis was, from the point of appearance alone, of two qualities: I. dull, smoky-grey, glassy fragments in abundant quantity, II. pale, greenish-grey, clear, glassy fragments of which somewhat less than four grammes were available. Both qualities contained large numbers of vesicles, and the determination of specific gravity in the massive state was regarded therefore as futile. The determination of the specific gravity in the finely powdered form was, however, made in the case of I, all precautions being taken to remove entangled air from the powder by gently boiling with water under reduced pressure, in the specific gravity bottle used for the determination.

The specific gravity of the powder, referred to water at 14.2°C., was found to be 2.296.

The preparation of samples for analysis presented no difficulties whatever, since the glassy material shatters with the greatest ease. Moreover, the rapidity of attack of the usual reagents rendered it unnecessary to grind any portion to an impalpable powder. Crushing in a steel mortar was carried on only until the whole of the selected fragments had passed through a 90-mesh sieve.

As with all very siliceous rocks, fusion with sodium and potassium carbonates yielded nice clear melts, and in neither case did the colour of the solidified cake give any suggestion of the presence of manganese. The fused mass, after disintegration with hydrochloric acid, was evaporated to dryness on the water bath and then baked in an air oven at 130° C. for 1-2 hours. This procedure has been found to reduce the non-insolubilized

silica to a practical minimum of about 2 milligrammes. The successive evaporations recommended in the treatises on the subject, while they may reduce this amount still further, do not result in the dehydration of the whole of the silica, reliance being placed on the ammonia precipitation for the recovery of the small amounts of silica still remaining in solution. Considerable economy in time is thus effected without in any way sacrificing accuracy. The complete removal of the last traces of insolubilized silica from the evaporating basins is a matter of great difficulty; a visible film remains after the most painstaking efforts of wiping with pieces of damp filter paper. The extent of the loss thus involved was investigated subsequently, using a platinum basin from which this film could be removed chemically with hydrofluoric acid; the adhering silica amounted to slightly less than 1 milligramme ($\approx 0.1\%$ on a 1 grm. sample). This refinement could be introduced with advantage in certain special cases and if facilities were available.

Metals of the H_2S group were absent from I and the test was therefore not applied in II.

The separation of the ammonia precipitate calls for the greatest care, for it is in this operation that so many things can go wrong. A fruitful source of error lies in the ammonia itself. Long storage in bottles leads to the solution from the glass of both silica and alumina, and quite frequently the ammonia in reagent bottles has absorbed sufficient carbon dioxide to carry down in this group some calcium as carbonate. The commercial ammonia is therefore redistilled and kept in a heavily waxed bottle for use in all high class work.

The tendency of magnesium to be partially precipitated in this group is greater than is usually appreciated, and herein lies the fundamental necessity for dissolving and re-precipitating this group. No separation of aluminium and iron from calcium and magnesium will be complete unless the ammonia precipitate has been dissolved and re-precipitated at least once.

Precipitates of aluminium and ferric hydroxides should always be washed with a 2% solution of ammonium nitrate to suppress the formation of colloidal solutions; even so, the recovery of "dissolved" alumina from the filtrates should be made as a matter of course, and is best carried out after concentration to small bulk.

The addition of filter paper pulp prior to the precipitation with ammonia confers advantages quite out of proportion with the simplicity of the operation. Though it increases the bulk of the already voluminous precipitate still further, the fibres impart to it a porosity which makes for easy filtration and washing, both of which operations are extremely tedious with the ordinary gelatinous precipitates produced by ammonia. The subsequent ignition of these "pulp" precipitates yields a light porous mass which dissolves with great readiness in the pyrosulphate fusion. This is in marked contrast with the slow attack of the hard gritty nodules obtained by the older method.

To prepare the pulp, a 9-cm. ashless filter paper is torn into small fragments and drenched with about 5 c.cs of strong hydrochloric acid in a small flask. After a few minutes, water is added and the mush violently shaken to separate the fibres. The pulp is then strained off on a Gooch crucible, and washed once or twice, when the pad is removed to the precipitation vessel and disintegrated with a stirring rod.

The author of this section, G. A. Ampt, has adopted the practice of co-precipitating both manganese and nickel with the usual Group IIIA elements by adding a little bromine water to the hot ammoniacal liquid. The use of ammonium persulphate for this purpose is generally admissible, and is equally effective, but where appreciable quantities of lime are present it may lead to the precipitation of some calcium sulphate. The manganese and nickel thus find their way into the ignited "mixed oxides," as Mn_3O_4 and Ni_3O_4 , and may be determined in aliquots of the solution of the pyrosulphate melt, the manganese colorimetrically after oxidation with sodium bismuthate, and the nickel by the glyoxime method. Both methods are capable of great accuracy, and even unweighable amounts of these oxides are readily detected. As a rule, the solution of the pyrosulphate melt is made up to 250 c.cs and used in the following manner: (i.) 100 c.cs for determination of total iron by reduction with zinc sulphide emulsion and titration with standard permanganate (4); (ii.) the same aliquot used for the glyoxime test for nickel, (iii.) 50 c.cs for the determination of manganese by the bismuthate process, (iv.) 50 c.cs for the determination of phosphoric anhydride, (v.) 10 c.cs for the colorimetric determination of titanium dioxide.

Neither manganese nor nickel was detected in either sample of Darwin Glass; a perceptible, though very minute precipitate of the yellow phospho-molybdate was obtained from I, indicating the presence of a trace of P_2O_5 , while in II the test gave an absolutely negative result.

Ammonium sulphide produced a slight precipitate in both filtrates from the ammonia group; it was found to be mainly sulphur with a little platinum sulphide (from the crucibles), but it contained no cobalt.

Lime was present in minute amount (0.05%) in I, but could not be detected in II. This is interesting, and probably significant, in view of the distribution of P_2O_5 .

Total water was determined by heating half-gramme portions in a small furnace and collecting the vapour in weighed absorption tubes. Control tests were made both with pure sodium bicarbonate (0.1 grm.) and with minute glass bulbs holding from 0.005 to 0.01 grm. of water, before the tests on the rock were undertaken. The weight of water collected, viz. I—0.46%, II—0.36%, showed remarkable agreement with the loss in weight suffered by the samples after correcting for oxidation of FeO to Fe_2O_3 , viz. I—0.43%, II—0.33%.

The determination of ferrous oxide was made by dissolving the sample in a mixture of hydrofluoric and sulphuric acids, the apparatus employed resembling that advocated by Treadwell (5, p. 207). The platinum crucible was supported within a small leaden chamber through which carbon dioxide was circulated, and which was heated to 120°C . by immersion in an oil bath. Darwin Glass, obsidianites, and similar highly siliceous and homogeneous materials yield readily to HF, and it is not necessary to grind them to impalpable powders with the consequent danger of oxidizing some ferrous oxide.

The following method has been adopted for many years for the alkalis in preference to that of Lawrence Smith. The mineral is disintegrated in a platinum dish on a water bath with a mixture of alkali-free hydrofluoric and sulphuric acids, whereby the whole of the silica is expelled as volatile SiF_4 . The solution is finally evaporated on a sand bath till fumes of SO_3 cease to be evolved and the residue is dry, but the heating should not be continued until the sulphates decompose, or sparingly soluble basic alums may be formed and alkalis lost. The sulphates after solution in water are treated with an excess of the purest solid barium hydroxide. This results in the complete precipitation of the sulphate radicle as BaSO_4 and of all the bases except calcium, the alkalis, and of course the excess barium, as hydroxides. The precipitate is filtered off and thoroughly washed (this is the only difficult operation in the process), and the filtrate is saturated with CO_2 and boiled down to small volume. Ba and Ca are thus thrown out as carbonates and are removed by filtration, while in the filtrate the alkalis are converted into chlorides and weighed. A few milligrammes of Ba invariably escape separation, and a series of small scale treatments with purest ammonium carbonate, filtrations and evaporations must be undertaken until the weight of the alkali chlorides is constant. It has never been found necessary to do this more than twice.

Potassium is separated as the platinichloride according to the usual procedure, but the final evaporation is made in a porcelain crucible with the addition of a little aqua regia to reoxidize any platinochloride formed by filtering the platinichloride through paper. The alcoholic filtrate containing the sodium platinichloride may be examined for lithium by means of the spectroscope.

The search for zirconium is now never omitted and is conveniently made on the same sample used for the detection of barium and sulphur. The determination as basic zirconium phosphate is somewhat tedious on account of the tendency of this salt to carry down others from which it must be purified by re-treatment. The presence of zirconia in sample II could not be definitely established, but barium, and sulphur in all forms, were absent from both specimens.

Owing to lack of material, further tests on II had to be abandoned. No. I was examined for carbonate in a miniature baryta-vacuum apparatus capable of detecting less than half a milli-

gramme of CO_2 (6, p. 251)—none was found. The examination for chlorides was unsatisfactory and inconclusive. Owing to the inability to obtain chlorine-free sodium carbonate, a blank test yielded an amount of chlorine many times greater than that which it should be possible to detect. If present, however, the amount would not exceed 0.05%.

The complete analyses together with those of Ludwig are given in the following table:—

Analyst		Ampt		Ludwig	
Appearance		I. Smoke grey, full of vesicles	II. Pale greenish grey, many vesicles	III. Olivine green	IV. Dirty white
SiO_2	-	86.34	87.00	88.764	89.813
Al_2O_3	-	7.82	8.00	6.127	6.207
Fe_2O_3	-	0.63	0.19	—	0.258
FeO	-	2.08	1.93	1.238	0.895
MnO	-	nil	nil	tr.	tr.
MgO	-	0.92	0.82	0.575	0.727
CaO	-	0.05	nil	0.174	—
Na_2O	-	0.15	0.14	0.129	0.010
K_2O	-	0.87	0.99	1.363	1.054
H_2O	+	0.43	} 0.36	—	—
H_2O	—	0.03		—	—
CO_2	-	nil	nil	—	—
TiO_2	-	0.52	0.51	1.240	0.867
P_2O_5	-	tr.	nil.	—	—
ZrO_2	-	0.11	tr. (?)	—	—
Cr_2O_3	-	nil	nil	—	—
NiO, CoO	-	nil	nil	—	—
BaO, SrO	-	nil	nil	—	—
SO_3	-	nil	nil	—	—
Cl	-	nil (?)	nil (?)	—	—
		99.95	99.94	99.610	99.821
Sp. Gr.		2.296	—	2.921	2.845

These four analyses have been classified according to the Quantitative Classification with the following results. The analyses are given in the same order as before.

		I.	II.	III.	IV.
Quartz	-	79.80	80.28	81.24	84.78
Orthoclase	-	5.00	5.56	8.34	6.12
Albite	-	1.05	1.05	1.05	—
Anorthite	-	0.28	—	.83	—
Corundum	-	6.53	6.73	4.08	5.10
Hypersthene	-	4.43	4.61	1.76	1.80
Magnetite	-	0.93	0.23	—	0.46
Ilmenite	-	1.06	0.91	2.28	1.67

All the analyses fall into Class 1 Persalane and Order 1 Perquaric. Rangs and sub-rangs are not considered necessary in this group. Only three analyses are quoted by Washington (7) in Class 1 Order 1.

VII.—Correlation with kindred Bodies, such as Moldavites, Australites, Billitonites, Schonite.

It has been shown by one of the authors (8) that all the other forms of Tektites of which analyses have been made fall into rangs and sub-rangs in the Quantitative Classification in which very few examples of normal igneous rocks are found. This is now shown to be equally true in respect to the Darwin Glass, so that rocks having compositions at all comparable with those of the Tektites are extremely rare among the igneous rocks of the earth's surface. At the same time, however, the strong similarity in composition of the various Tektites to one another is well shown by their relative positions in the Quantitative Classification.

The analyses of Australites, Billitonites and Moldavites have been compared by one of us (9) by means of variation diagrams. Suess (1) has also used a somewhat different form of variation diagram which includes in addition Ludwig's two analyses of Darwin Glass (Queenstownite). Variation diagrams are usually compiled either from the percentages of oxides as given by the analyses or from the molecular ratios determined from these percentages. The second form is that used by Suess. The summations of analyses and the percentages of water present vary. In some cases TiO_2 is not determined and in other cases the ferrous and ferric oxides have not been separated. If the molecular ratios are determined the totals for different analyses will vary greatly, so that in either case the analyses are not strictly comparable.

The molecular ratios give a better conception of the relative proportions of the oxides than do their percentages by weight. In order to obtain more satisfactory graphing, the molecular ratios of the various types have been determined from the analyses and then reduced to percentages. The water, both combined and hygroscopic, has been omitted and the TiO_2 reduced to Ti_2O_3 . This latter is quite open to question, but the amount of titanium is small and the effect is practically negligible. The reduced analyses are given in the following table:—

	Darwin Glass Tasmania (Ample)	Darwin Glass Tasmania (Ample)	Darwin Glass Tasmania (Ludwig)	Darwin Glass Tasmania (Ludwig)
XXII. XXIII. XXIV. XXV.				
SiO ₂	90.7	91.1	92.5	93.2
Ti ₂ O ₃	0.2	0.2	0.5	0.3
Al ₂ O ₃	4.8	4.9	3.8	3.8
Fe ₂ O ₃	0.3	0.1	—	0.1
FeO	1.8	1.6	1.1	0.8
MgO	1.4	1.3	0.9	1.1
CaO	0.1	0.0	0.2	0.0
Na ₂ O	0.1	0.1	0.1	0.0
K ₂ O	0.6	0.7	0.9	0.7
Total	100.0	100.0	100.0	100.0

The percentages of molecular ratios have been graphed. In text-figure 2 the sums of the R₂O₃, RO and R₂O oxides are shown and for comparison those of some average compositions of the common more acid plutonic rocks are also given. Undoubtedly it would have been preferable to use average volcanic rocks rather than plutonic but up to the present similar averages of analyses of volcanic rocks have not been worked out.

In testing Daly's (10) averages for granites, quartz-monzonites, granodiorites, quartz-diorites, diorites, gabbros and norites by means of variation diagrams it was found that the various points for the percentages of the molecular ratios of the R₂O₃, RO and R₂O molecules fell practically on straight lines. Following this up all the better analyses of the above mentioned rocks quoted by Washington (7) were reduced to percentages of molecular ratios and graphed. Some analyses showed considerable deviation from the general average and were rejected as being probably not true to name. A series of averages was then calculated and the averages of the more acid types are shown on the diagram by crosses.

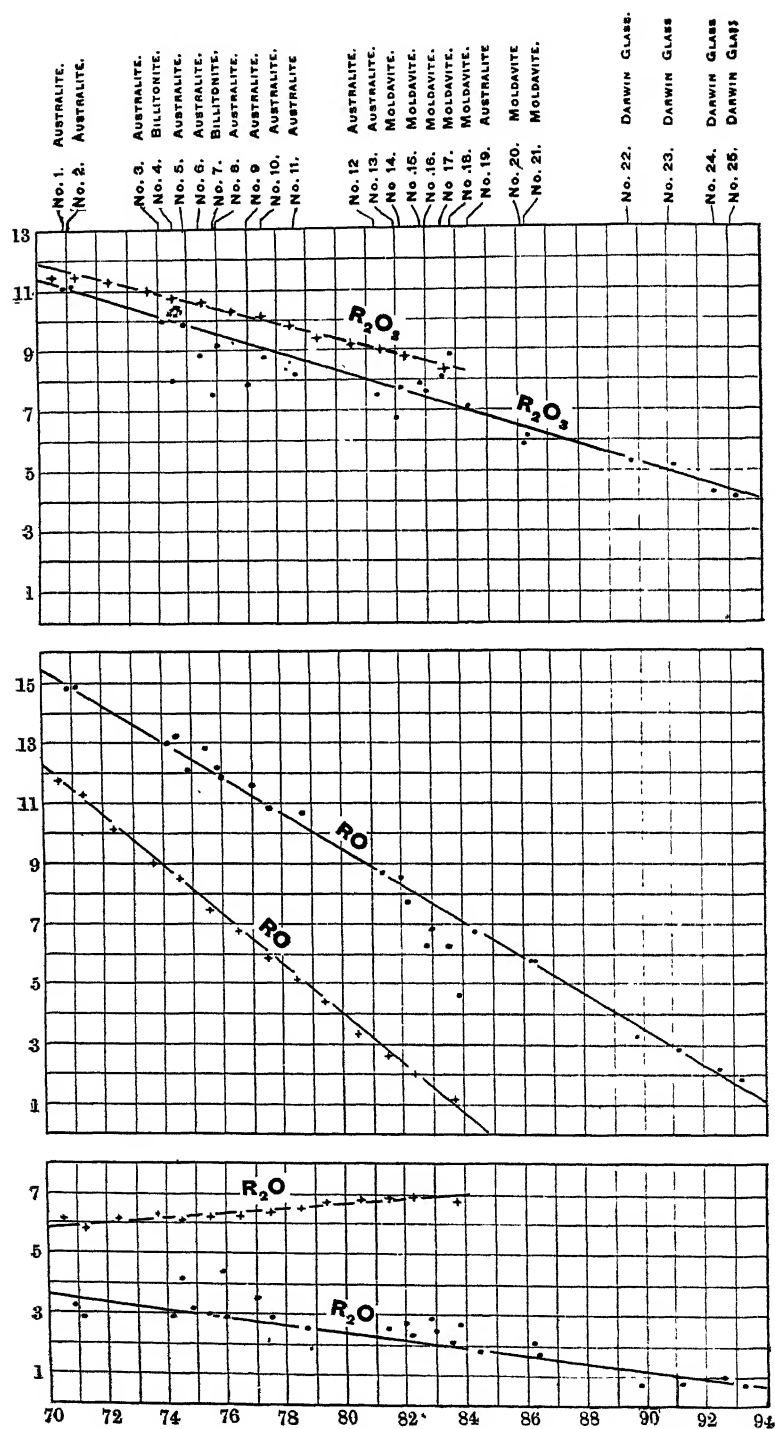
In text-figure 3 the graphs of the percentage molecular ratios of the individual oxides of the Tektites are given.

These variation diagrams strongly support the contention that the Tektites are all genetically related to one another and clearly show the close relationship in composition of the Darwin Glass to the remaining forms.

A comparison of the graphs for the Tektites with those for the common acid plutonic rocks shows that the two series are quite distinct in composition.

VIII.—Distribution of Tektites on the same Great Circle.

What is probably an extremely significant fact about Darwin Glass, in common with other Tektites, is that they all lie approximately on the same great circle.

FIG. 2.—GRAPHS OF SUMS OF R_2O_3 , RO AND R_2O OXIDES IN TEKTITES.

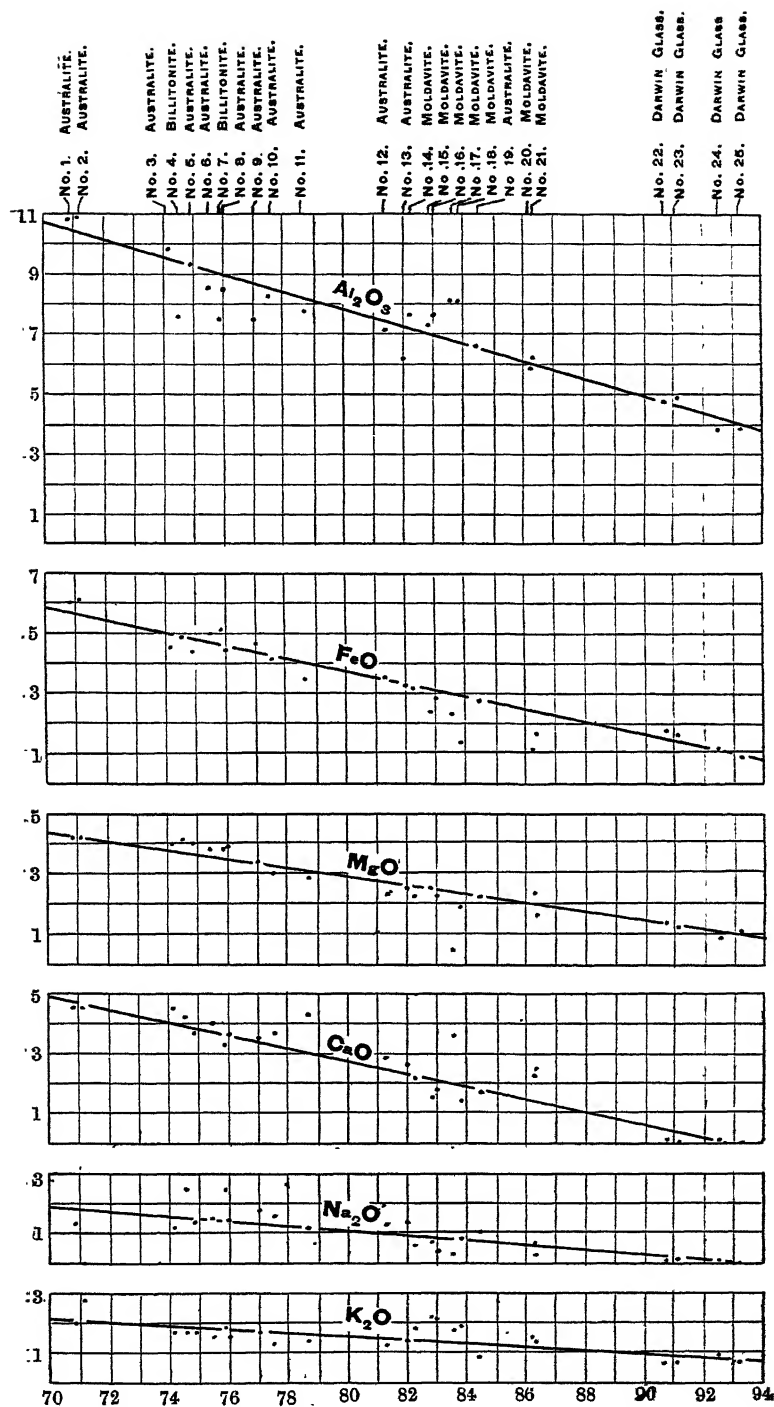
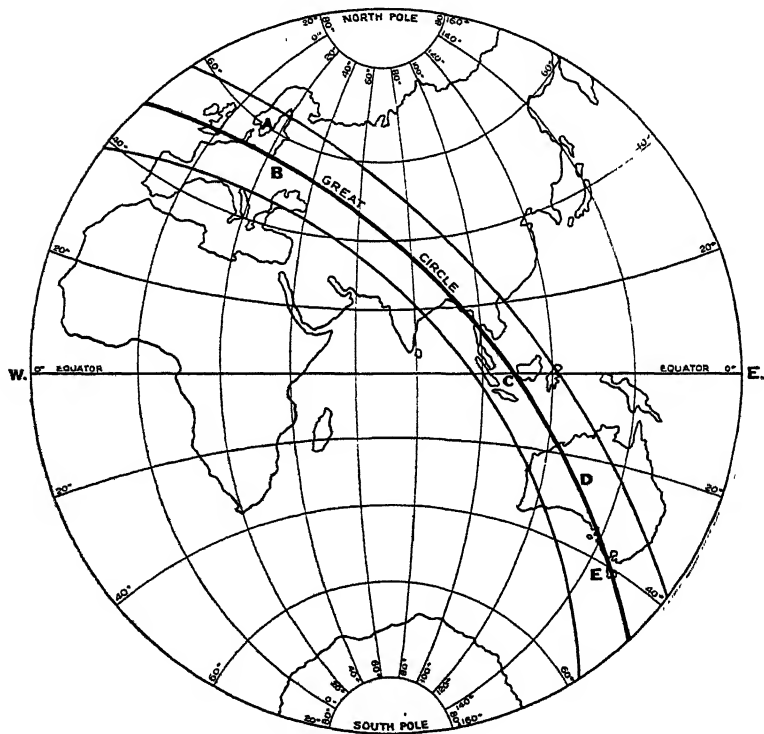


FIG. 3—GRAPHS OF PERCENTAGE MOLECULAR RATIOS OF INDIVIDUAL OXIDES IN THE TEKTITES.

If Tasmania be taken first it has Darwin Glass very plentifully, but also very locally, distributed, over a region in the south-west, upon and around Mount Darwin. No Australites, so far, have been found in this part of the island. Further north Australites occur, frequently several together in one group. The shower of Australites spread over Victoria, New South Wales, the southern

Map on Stereographic Projection showing Great Circle γ_{20} with belt on each side of it 10° wide, indicating that all the known tektites of the World lie approximately on the same Great Circle.



- A. *Schonit* of Sweden
- B. *Moldavites* of Moldau River, etc.
- C. *Billitonites* of Banca, Billiton and S. Borneo.
- D. *Australites* of Australia.
- E. *Darwin Glass* and *Australites* of Tasmania.

FIG. 4.

extremity of Queensland, South Australia, and Central Australia, to beyond Charlotte Waters, and as far north west as the Tanami goldfield, Western Australia, where they appear to be specially abundant in the neighbourhood of the Coolgardie-Kalgoorlie gold-

field. Northwards they have been traced to about half way between Wiluna and Hall's Creek on the Canning Stock Route. They have also been found a few miles inland from the coast near Wallal. They are thus strung out over an area about 2000 miles in length, from about E.40°S. to W.40°N. If this bearing be now followed on a great circle, it leads to Java, the south-eastern portion of Borneo, Banca and Billiton where the kindred bodies, Billitonites, occur somewhat plentifully. Following the same great circle, one finds, after a long interval, that one reaches Moldavia, where, of course, the closest allies of Darwin Glass, Moldavites, are very abundant and somewhat widely distributed. Again, on the same great circle, we find an isolated occurrence, in Scandinavia, of Schonite. In view of this remarkable distribution, there would seem to be a high probability that all these five bodies of Tektites belong to one and the same group of meteorites. They seem to have been either discrete swarms of small meteorites, or represent the scorification products of separate, larger bodies, which became, to a great extent, disrupted probably in their passage through the Earth's atmosphere. The distribution of the ultra-acid glasses, Moldavite and Darwin Glass, at the two extremities of the belt occupied by the Tektites (with the solitary exception of the Schonite) suggests an original gravitational separation of the meteoritic swarm into more siliceous portions on the periphery, and more basic types towards the centre. Though one is not sure of the sense of the movement, it may be assumed that as the swarm approached the earth, it became so greatly elongated towards the earth that the ring of acid meteorites was more or less disrupted into a vanguard and rearguard. The vanguard arrived in Tasmania, the main body fell over Northern Tasmania, Australia, and the Netherlands East Indies, and the rearguard, separated by a considerable distance, fell in Moldavia.

IX.—Hypotheses as to Origin.

Hypotheses as to the origin of the Tektites other than Darwin Glass have been discussed at length by many authors (see bibliographic lists by Suess (1) and Summers (8)). The origin of the Darwin Glass has also been discussed by Suess and Loftus Hills (2). The hypotheses may be summarised as follows:—

(a) *Artificial.*

As recorded by Loftus Hills, this glass was not at first recognized as something unique owing to the material being found in the vicinity of copper smelting works at Crotty. Thus the glass was presumed to be simply a furnace slag. The analyses of course disprove this and the mode of occurrence and distribution also show that such an origin is impossible, as white men had only penetrated the area for about seventeen years at the time of

the first discovery of Darwin Glass and the area had never been settled. The Tasmanian aborigines cannot be seriously considered as a factor in the distribution of a substance which does not occur naturally as a volcanic product and which they were incapable of producing artificially.

(b) *Volcanic.*

The Darwin Glass is certainly not earlier than the late Tertiary period. The principal volcanic rocks of this period in Tasmania and Victoria were basalts with occasional andesites and trachytes. The undevitrified nature of the glass precludes the possibility of this material being derived from any pre-Tertiary glassy igneous rocks. Therefore the only volcanic sources to which this material could be ascribed produced either basic or intermediate volcanic rocks only. The silica percentage in the Darwin Glass, approximately 88%, makes it even more difficult than in the case of the Australites, silica percentage 65 to 76, to suggest a local volcanic source. So far those holding the view that Australites are of volcanic origin have failed to suggest an Australian source which can be reasonably accepted. This led to the suggestion that the possible source was New Zealand or the East Indies. No rocks from these areas have been shown to be comparable in composition with the Australites, although some show a sufficiently high silica percentage. Even granting the possibility that the volcanoes from these areas might have produced material of the requisite composition, the transport of the material over such great distances cannot be ascribed to normal volcanic agencies. E. J. Dunn (11, 12, 13) has postulated the bubble hypothesis for the transport of Australites but it seems quite impracticable to extend this idea to cover the case of the Darwin Glass, even if it were accepted as a possible explanation of the distribution of Australites. If we are to believe that the Darwin Glass is of volcanic origin we must also believe that there exists in the neighbourhood a volcano which produced the glass.

If we consider the composition of the Darwin Glass we find that the hypothetical volcano would be required to produce a unique volcanic glass. The highest percentage of silica in an obsidian recorded by Washington is Dunn's so-called marekanite from New Zealand, with approximately 77% SiO_2 . The Darwin Glass averages approximately 88% SiO_2 . Richards (14) records an analysis of a rhyolite from Blackall Ranges, Queensland, with 85.13% SiO_2 , and also quotes examples of other highly siliceous rocks. In all these cases, however, evidence of secondary silicification is noted and the compositions as given do not represent the original compositions at the time of extrusion. In the case of the Darwin Glass, if secondary silicification were accepted as a possible explanation of the high silica percentage, it would be necessary to assume that subsequently refusion of the material had taken place, to account for the absence of devitrification and

absence of evidence of the presence of secondary silica. Taking into account the absence in the neighbourhood of evidence of contemporary volcanoes producing even normal acid rocks, and also the abnormal composition of the Darwin Glass, we have no hesitation in rejecting the hypothesis of a volcanic origin for these Tektites.

(c) *Fulguritic.*

(i.) *From fusion of siliceous sands at surface of ground.*

The records of the occurrence of fulgurites are comparatively few, and the plentiful distribution of the Darwin Glass has no parallel in such records. An examination of a fulgurite from New South Wales presented to us by Mr. Card shows that an open tube about $3/16''$ in diameter runs throughout the specimen. Surrounding this tube the material is for the most part quite glassy but towards the margin the vitreous appearance is lost and this portion consists of only partially fused material. This is confirmed by an examination of a cross section of the fulgurite under the microscope. The central area is glassy but the outer portion affects polarized light and simulates incipient devitrification. This appearance is, however, probably due to incomplete fusion of the original particles rather than to subsequent alteration from an isotropic glass.

This specimen of course cannot be taken as being typical of all fulgurites but shows that in this case there is very marked dissimilarity between the fulgurite and the Darwin Glass. According to Loftus Hills the Tektites are found lying directly on limestone in soil wholly composed of peat and the residuum from the decomposition of the limestone, and also in other places resting directly on quartzite. Since, as pointed out by Loftus Hills, a fulgurite must necessarily correspond approximately in composition with the surrounding material of which it is a fused portion, it is inconceivable that fulgurites of similar composition and appearance could be formed under such different conditions. The evidence therefore is distinctly against a fulguritic origin for the Darwin Glass.

(ii.) *From fusion of dust clouds in a thunderstorm.*

Fusion of dust clouds by lightning discharge has been suggested as a possible explanation of the formation of Australites. This idea while suggesting a possible source of the Australite does not explain their distribution or similarity in composition. This hypothesis postulates an exceptionally dense dust cloud and the production from this by means of lightning discharge of moderate sized pieces of a perfectly fused glass, a phenomenon which has never been recorded in any part of the world. A large proportion of the Australites are found in places in which dense clouds are by no means uncommon but the Darwin Glass is only found in an area, at the present time of heavy rainfall, and in which dust storms similar to those of Central Australia are im-

possible. There is no evidence to show that arid conditions existed in this area during Pleistocene times, but rather the reverse, as it has been shown earlier that the Darwin Glass was probably contemporaneous with the Pleistocene glaciation of Western Tasmania. Should such a fusion of dust take place one would expect the product obtained to be more related to the fulgurites than to a perfectly homogeneous glass, i.e., the mass would consist of fused material together with a considerable amount of only partially fused dust particles. No evidence of such fritted material has been seen.

(d) *Meteoritic.*

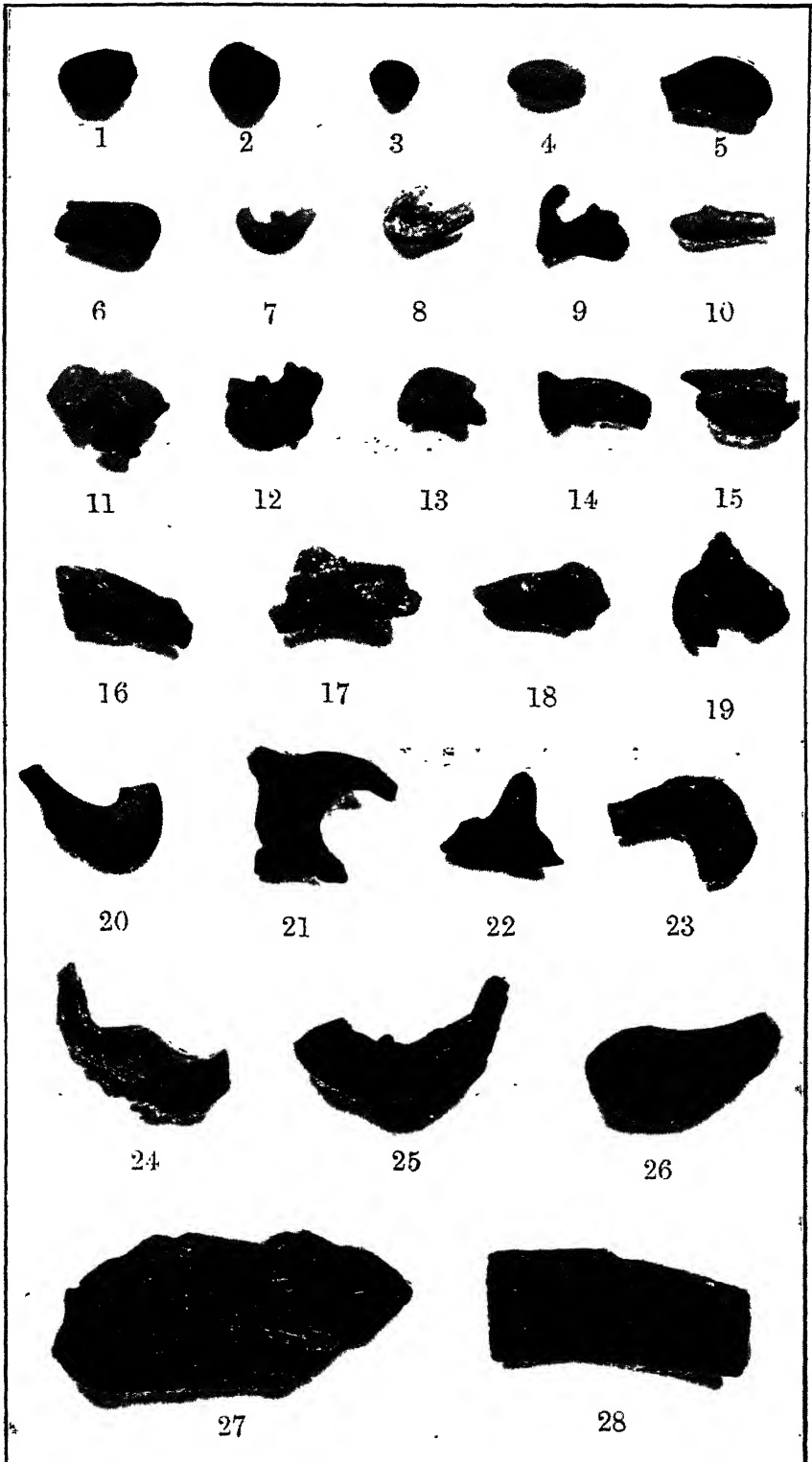
As other hypotheses have failed to account for the composition, form and distribution of the Darwin Glass, the meteoritic origin of this material must be considered. The majority of those who have seriously investigated the origin of the earlier known tektites are convinced that they are of extra-terrestrial origin. The composition and mode of occurrence show that the Darwin Glass is closely related to the Moldavites, Australites and Billitonites and we infer that they had a common mode of origin. Unfortunately no positive evidence of a meteoritic origin of the Tektites has been found and such evidence could only be obtained by the actual observation of a similar shower in the future. On the other hand no unanswerable arguments have been advanced against this hypothesis as being able to explain the source, form, composition and distribution of the Tektites.

Conditions must have been somewhat different in the different areas as the forms vary greatly. All are isotropic glass, so that they must have cooled rapidly from a molten state. In the case of the Australites, the characteristic forms are believed to be due to rotation of liquid bodies modified by the resistance of the atmosphere.

A similar explanation of the forms of the Moldavites is not possible, as they are quite irregular and the characteristic forms of the Australites seem to be entirely absent. The fusion surfaces on certain Moldavites described by Weinschenk (15) suggest that only partial fusion of these bodies took place during their flight through the atmosphere.

This explanation would assume that the Moldavites were glassy bodies before entering the earth's atmosphere. Alternatively the Moldavites may represent fragments of some larger body or bodies which exploded fairly close to the earth's surface and consequently the fragments had not sufficient time to assume the forms developed by rotating fluids. Some portions may have had their flight sufficiently checked by the explosion to solidify and partial refusion of the surface may have been due to their subsequent reacceleration under the action of gravity.

In the case of the Darwin Glasses their fragmental nature is apparent and is most satisfactorily explained as the result of the



Darwin Glass, Tasmania.

rupturing of some larger body or bodies. The majority of the specimens are somewhat analogous to forms produced by the violent ejection of molten lava from volcanoes, and thus the explosion of a molten mass, meteoritic in origin, might well produce the varying types which have been observed. The vesicular nature of most specimens of the Darwin Glass indicates that such explosion could be due to the expansion of the included gases.

It has been stated that all authentic meteorites are either metallic or ultrabasic in composition: therefore such acid material as the Tektites cannot be meteoritic in origin. Since the meteorites are probably derived from the disruption of a larger body, if such body had a composition at all comparable with that of the Earth we should expect to find a very large proportion of metallic meteorites a fairly large proportion of ultrabasic meteorites and comparatively few acid meteorites.

As pointed out earlier there is no positive evidence at present to support the meteoritic hypothesis of the origin of the Darwin Glass, but as all other hypotheses have been shown incapable of explaining their composition, distribution, etc., whereas the meteoritic hypothesis apparently is capable of so doing, we have no hesitation in accepting the meteoritic hypothesis as having the balance of evidence in its favour.

X.—Summary and Conclusions.

A full description of the distribution, with map, and the occurrence of the Darwin Glass is given and the explanation due to Mr. Hartwell Conder of their non-occurrence on the upper part of Mount Darwin is recorded. This explanation, if correct, is very important, as it fixes the age of the Darwin Glass as contemporaneous with the Pleistocene glaciation of Tasmania.

The form and general physical characteristics of the Darwin Glass are given in some detail.

Two fresh analyses of Darwin Glass are recorded and the methods used to obtain a high degree of accuracy are described.

The correlation of the various Tektites is discussed and by means of variation diagrams etc. it is shown that they are all genetically related to one another.

The interesting fact that all the Tektites recorded occur either along or close to the same Great Circle is recorded and this distribution is shown on the map of the Eastern Hemisphere. This map suggests that further discoveries of Tektites may be made in South-Western Asia.

The various hypotheses as to the origin of the Tektites is discussed and by a process of elimination the conclusion is reached that they are meteoritic in origin.

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[PART II. PUBLISHED 18TH OCTOBER, 1927.]

ART. VI.—*A Revision of the Genus Pultenaea. Part V.*

By H. B. WILLIAMSON, F.L.S.

[Read 13th October, 1927; issued separately 21st April, 1928.]

PULTENAEA MOLLIS Lindley.

An attempt is here made to clear up the difficulty involved in this species, a difficulty which seems to have arisen from an error in the determination of Robertson's Mt. Sturgeon specimens as *P. viscosa* R.Br., Fl. Aust., II., 127. Referring to Revision, Part III., *Proc. Roy. Soc. Vic.*, p. 107, it may be taken as certain that the specimens collected (a) by Robertson, Fl. Aust., II., 127; (b) by Mueller about 1855; and (c) by the author were the same species. The leaves are scarcely to be distinguished from those of the Clyde Mt. and Parramatta specimens of *P. viscosa* R.Br., and Mueller determined (a) and (c) as *viscosa*. Specimens (b) and (c) have been determined at Kew as *P. mollis* Lindl., as they agree with those distributed by Lindley, and which are considered at Kew as portions of the plant gathered by Mitchell and given to Cunningham. Mueller determined his own specimens as *P. mollis*, and they agree exactly with those of the author, who in conversation with the distinguished botanist in 1895 learned that 40 years before the locality had been the site of his camp on the Wannon.

It seems, therefore, that *P. viscosa* has been wrongly recorded for Victoria. In view of the fact that Bentham's description was framed to include the Mount Macedon specimens of Mueller, which now must be kept distinct, and the true *mollis* of Lindley, which is so close to the more recently described *P. viscosa*, it must for a time be doubtful whether this species should have been set up at all. The plant which has been accepted by Victorian collectors as *P. mollis* (Grampians, Mt. Macedon, Gembrook, and recently Bairnsdale, T. S. Hart), differs materially from the type which appears to be confined to the southern Grampians, the Wannon River and Portland, and as all these specimens agree on the whole with the Mount Macedon specimen collected by Mueller, it had better be kept distinct as *P. angustifolia*, Mueller's MS. name on the label. A description is here given.

PULTENAEA ANGUSTIFOLIA (F.v.M. Herb.), sp. nov.

Frutex circiter 2 m. altus, ramulis pubescentibus, foliis tenuibus fere teretibus 10-20 mm. longis glabris vel pubescentibus, floribus breves ramos terminantibus in capitula (5-7 fl.) congestis pedicellis 2-3 mm. longis, stipulis minimis nigris recurvatis, bracteis latis pedicellis brevioribus plerumque bifidis, bracteolis latis saepe viscosis nonnumquam carinatis arcte appressis tubo

calycis aequilongis, calyce fere glabra lobis subaequalibus obtusis vel subacutis superioribus paulo latioribus quam inferiora, ovario villosa.

Mt. Macedon, Mueller; Gembrook Ranges; Grampians; Bairnsdale (T. S. Hart, Sept., 1927).

Var. *VISCOSA*, var. nov.

Calyce bracteis et bracteolis viscosis.

The form from the Grampians, Vic., with its calyx, bracts and bracteoles viscosus and its leaves rather longer.

The relation of the foregoing species to each other is shown thus:—

A. Leaves almost flat.

B. Leaves incurved, flowers densely crowded in a head (7 to 10) on very short pedicels, bracteoles half the length of the calyx. *P. mollis.*

B. Leaves almost straight, flowers in heads (5-6) not crowded, on pedicels 2-3 mm. long, bracteoles nearly as long as the calyx. *P. viscosa.*

A. Leaves thin, terete, channelled above, flowers not densely crowded, on pedicels 2mm. long, bracteoles short and broad. *P. angustifolia.*

Calyx viscosus.

var. *viscosa.*

PULTENAEA HIBBERTIODES Hk. f.

var. *PROSTRATA*, var. nov.

Frutex prostratus, foliis et floribus valde confertis.

A prostrate form with much crowded leaves and flowers. Waterloo Bay, Wilson's Prom., Nat. Park, J. W. Audas, Nov., 1908. The flowers of var. *conferta* Bth., Cobden, S.W. Vic., are much crowded, but its leaves are not distinctly so as in this form. This is evidently the plant that has been recorded from Georgetown, North Coast of Tasmania.

PULTENAEA KENNYI H.B.W.

=*P. microphylla* Sieber var. *cuneata* Bth.

This agrees with the var. *cuneata* Bth. in *Ann. Wien. Mus.*, ii., 83 (Fl. Aust., II., 117). As from this form to the normal *P. microphylla* a series of intermediates as regards width of leaves has been examined, the plant should still retain varietal rank only.

PULTENAEA FOLIOLOSA Cunn.

Benth. in *Ann Wien. Mus.*, ii., 83.

This plant has very small leaves, often only 1 mm. long, almost orbicular, crowded on short branchlets of 1-2 cm. long, at the ends of which are a few flowers in the axils. Stipules are hairlike, nearly as long as the leaves, and the bracteoles are similar to the leaves, and provided with hair-like stipules. The calyx is about 4 mm. long, with lobes not longer than the tube; the two upper

ones much falcate and united to the middle. The ovary is glabrous except for a tuft of white hairs.

The type of this species came from westward of the Wellington Valley, N.S.W., A. Cunn. There are specimens from Lachlan River, Fraser; Darling Downs, Q., Mrs. Ford; Texas, Q., Boorman; Eastern Downs, H. Law. The form from Chiltern, "Mayday Hills," "Between Meadow Creek and King River," N.E. Victoria, differs from the normal in size of flowers and leaves, the latter reaching 4 mm. in some specimens. It shows a transition towards *P. styphelioides* Cunn. through its intermediate var. *mutica* F.v.M., having often lanceolate bracteoles fixed high upon the calyx. From New England, N.S.W., there is a plant which so much resembles *P. foliolosa* in general appearance that it is little wonder that it has been placed under that species. Its remarkable calyx, however, renders it quite distinct, and with the concurrence of the authorities at Kew it is now described, the species name being in honour of the collector of the Tenterfield specimen.

PULTENAEA STUARTIANA, sp. nov.

Frutex parvus, ramulis numerosis brevibus, foliis minimis raro 2 mm. longis ovato-orbicularibus supra concavis infra scabridis apice recurvatis, stipulis parvis, floribus fere sessilibus in axillis superioribus, bracteolis foliaceis quasi stipulatis, calyce 4 mm. longo villosa lobis latis tubo longioribus oblongis inter se aequilongis et formâ similibus superioribus non falcatis, ovario glabro apice comam gerente.

New South Wales: Tenterfield, C. Stuart; Torrington, J. L. Boorman.

This differs from *P. foliolosa* Cunn. in having the long lobes of the calyx similar in size and shape.

PULTENAEA ACCROSA R.Br.

A record for this species in Victoria has been made, the plant having been gathered near Mt. William in the Grampians, J. W. Audas, Nov., 1923.

PULTENAEA GRAVEOLENS Tate.

This plant has apparently not been gathered in Victoria since Mr S. Johnson sent it to Mueller from Meredith many years ago, until with Mr. E. Cooper, senr., the author found it at Steiglitz in October, 1925.

ADDENDUM.

[Read 8th December, 1927.]

PULTENAEA PATELLIFOLIA, sp. nov.

Frutex fere glaber 0.5—1 m. altus, ramulis pubescentibus, foliis fere sessilibus alternatis late obovatis vel orbicularibus circiter 3 mm. longis latisque margine paululum incurvatis ad apicem recurvo-mucronatis supra glabris infra sparsim pubescentibus, stipulis parvis, floribus subumbellatis 3-6 ramulos terminantibus, pedicellis pilosis 5-6 mm. longis, bracteis parvis, bracteolis viscosis orbicularibus appressis vix 2 mm. longis subter tubum calycis affixis, calyce circiter 5 mm. longo fere glabro lobis fere aequalibus tubo brevioribus, vexillo luteo lineis atro-rubris instructo, alis luteis, carina atro-rubra, ovario villosa in stylum subulatum extenuato, legumine ovato-oblongo breviter acuminato, seminibus 2 distincte strophiolatis.

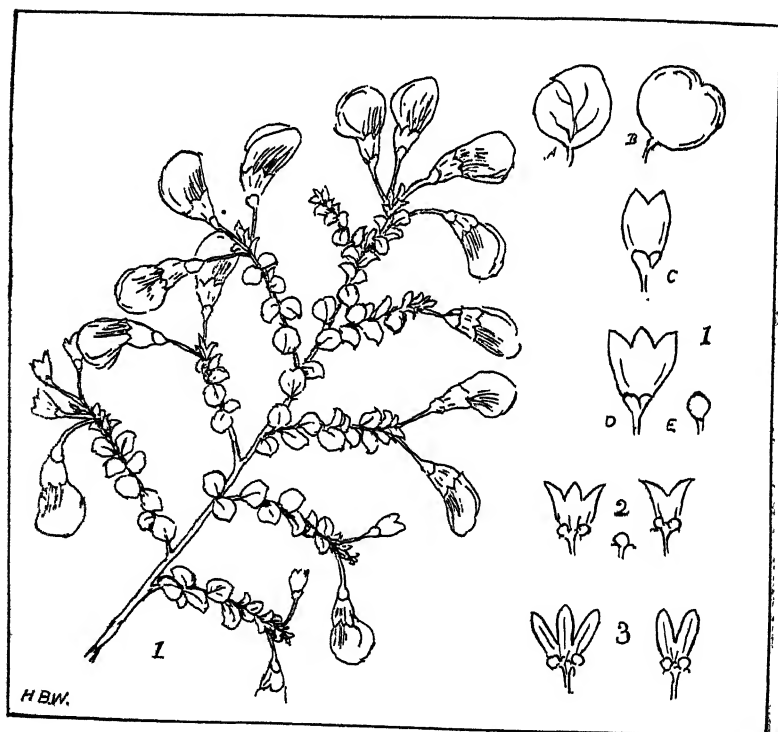


FIG. 1.

1. *P. patellifolia*—A, leaf, under side; B, leaf, upper side; C, upper calyx lobes; D, lower calyx lobes; E, bracteole.
2. *P. foliolosa*, calyx and bracteoles.
3. *P. Stuartiana*, calyx and bracteoles.

Mt. Byron, Black Range, Western Grampians, Vic., Mr. Harold Smith, October, 1927.

An almost glabrous shrub, $\frac{1}{2}$ to 1 m. high, with pubescent branchlets. Leaves almost sessile, alternate, broadly ovate to orbicular, many dish-shaped, about 3 mm. in diameter, with slightly incurved margins, and ending in a recurved mucrone, glabrous above, slightly hairy below. Stipules small. Flowers almost umbellate, 3 to 6, terminating the short branchlets, with hairy pedicels 5 to 6 mm. long. Bracts small. Bracteoles viscid, orbicular, appressed, scarcely 2 mm. long, and fixed below the tube of the calyx. Calyx about 5 mm. long, almost glabrous, with nearly equal lobes shorter than the tube. Standard yellow with dark-red lines. Wings yellow. Keel dark red. Ovary villous tapering into a subulate style. Pod ovate-oblong, shortly acuminate. Seeds two, with a distinct strophiole.

This graceful and very distinct species has some resemblance to *Bossiaea cordigera*, although it is not a scrambling shrub, but distinctly erect. It belongs to the Section *Coelophyllum*, and its nearest ally is *P. Vrolandii* Maiden, which it resembles in having viscid bracteoles forming a complete cup fixed just under the calyx; but in the case of *P. Vrolandii* this cup is inflated, and almost conceals the calyx, while in the new species it is very small, and tightly appressed to the calyx. The leaves are quite unlike those of any other *Pultenaea*, their dish-like appearance suggesting the specific name, and the umbel-like inflorescence with flowers on long pedicels is unusual in the genus. It may be remarked that although the flowers are at first terminal, the ends of the branchlets are somewhat produced after flowering, so that the flowers are not then strictly terminal.

The discoverer, Mr. Smith, handed the plant in at the National Herbarium, and the Government Botanist, Mr. Rae, noting that it was worthy of further investigation, instructed his senior assistant, Mr. Audas, to proceed to Horsham to obtain additional material. The author was invited to accompany him, and through the good offices of Mr. Smith a visit was paid to the locality, 38 miles S.W. of Horsham, where the plant was found in abundance both in the sandy soil at the foot and among the rocks at the summit of Mt. Byron. As a vernacular name "Mt. Byron Bush-pea" is suggested.

Pultenaea D'Altonii H.B.W.

New Locality: Mt. Talbot, towards Mt. Byron, J. W. Audas, October 30th, 1927. Previously recorded only from the Little Desert near Nhill (type locality), and from near Steiglitz.

ART. VII.—*Some Tertiary Volcanic Minerals and their Parent Magma.*

By D. J. MAHONY, M.Sc., F.G.S.

[Read 13th October, 1927; issued separately 21st April, 1928.]

In many Victorian scoria cones and bedded tuffs of Tertiary age, minerals much larger than the normal constituents of the associated volcanic rocks are found. These minerals may be free from other matter or embedded in vesicular basalt or may form the nuclei of volcanic bombs. Those examined are feldspars, hornblende, augite and olivine.

Feldspars.

ANALYSES OF FELDSPARS.

	1	2	3	4	5	6	7	8
SiO ₂	65.09	66.20	65.64	65.14	64.62	65.37	61.93	66.23
Al ₂ O ₃	21.86	22.60	21.18	20.92	22.90	21.56	22.08	19.97
Fe ₂ O ₃	0.30	tr.	0.05	0.31	0.40	—	tr.	0.49
FeO	0.08	—	nil.	—	nil.	—	—	—
MgO	0.05	0.38	0.21	0.18	0.14	—	tr.	0.17
CaO	1.93	1.92	1.55	1.42	1.30	1.67	nil.	0.50
Na ₂ O	8.66	8.05	7.45	7.43	7.29	7.35	8.84	8.07
K ₂ O	1.68	1.05	3.66	3.93	3.07	3.74	6.34	3.36
H ₂ O+	0.12	0.60	nil.	0.07	0.05	0.25	—	—
H ₂ O-	0.06	—	0.06	0.07	—	0.07	—	0.02
CO ₂	nil.	—	—	—	nil.	—	—	—
TiO ₂	0.04	—	nil.	0.03	tr.	—	—	nil.
P ₂ O ₅	nil.	—	nil.	—	nil.	—	—	—
MnO	0.02	—	—	nil.	tr.	—	—	—
Li ₂ O	strong tr.	—	—	tr.	nil.	—	—	—
SO ₃	nil.	—	—	—	0.32	—	—	—
Cl	tr.	—	—	—	nil.	—	—	—
NiO, CoO	nil.	—	—	—	nil.	—	—	—
BaO	0.02	—	—	—	nil.	—	—	—
SrO	0.16	—	—	—	nil.	—	—	—
ZrO	—	—	—	—	tr.	—	—	—
	100.07	100.80	99.80	99.50	100.09	100.01	99.19	98.81
Rating	A1.I	A2.II	A1.I	A1.I	A1.I	A2.II	B3.V	B3.V

FELSPARS: NORMS BY PERCENTAGE WEIGHT.

	1	2	3	4	5	6	7	8
Or	9.99	6.20	21.71	23.34	18.19	22.16	37.57	19.93
Ab	73.48	68.27	63.22	63.06	61.86	62.33	75.00	68.43
An	10.10	9.55	7.72	7.03	6.46	8.31	8.30	2.48
SiO ₂	3.67	10.53	4.42	3.32	7.27	4.54	—	4.50
Al ₂ O ₃	2.08	4.71	2.08	1.81	5.18	2.35	—	2.12
Enst.	0.12	0.94	0.52	0.45	0.35	—	—	0.42
Hy	—	—	—	—	—	—	—	0.90
Π	0.08	—	—	0.10	—	—	—	—
Mt	0.21	—	—	0.24	0.40	—	—	—
Hm	0.16	—	0.08	—	—	—	—	—
H ₂ O, etc.	0.18	0.60	0.06	0.14	0.37	0.32	—	0.02
	100.07	100.80	99.81	99.49	100.08	100.01	120.87	98.80

FELSPARS: MOLECULAR PERCENTAGES.

	1	2	3	4	5	6	7	8
Or	10.24	7.03	22.49	23.98	20.15	22.80	22.94	20.97
Ab	79.94	82.16	69.50	68.77	72.68	68.64	68.46	76.42
An	9.81	10.82	8.01	7.25	7.17	8.56	8.61	2.61
	99.99	100.01	100.00	100.00	100.00	100.00	100.01	100.00

1. Mount Lookout, Aberfeldy, Gippsland. Large crystal from vesicular basalt. Sp.gr. 2.618. Analyst, A. G. Hall.
2. Mount Lookout, Aberfeldy, Gippsland. Only about one gramme available for analysis. A duplicate determination gave alkalis 9.18%. Analyst, P. G. W. Bayly.
3. Mount Anakie, about 16 miles NNW. of Geelong. Sp.gr. 2.62. Analyst, F. F. Field.
4. Mount Franklin, near Daylesford. Sp.gr. 2.613. Analyst, A. G. Hall.
5. Mount Franklin, near Daylesford. Fine, cross-hatched twin lamellae. Analysts, Miss J. M. Robertson and C. E. Eales.
6. Mount Franklin, near Daylesford. Fine cross-hatched twin lamellae. Analyst, F. W. J. Clendinnen.
7. Magorra, near Junbunna, S. Gippsland. Glassy tabular crystals from dense basalt. Alkalis evidently too high. Analysis, Geol. Surv. Vic. Lab. (1901).
8. Mount Noorat, near Terang. Alkalis unsatisfactory on account of fusion and insufficient material for duplicate determinations in their case; duplicate determinations of the other oxides agreed closely. Sp.gr. 2.608. Analyst, A. G. Hall.

I am indebted to Professor H. S. Summers for analyses Nos. 5 and 6. The relative values of the analyses are indicated by using Washington's method of rating (1), the degree of accuracy being expressed by the letters A, B, C and D, and the degree of completeness by the figures, 1, 2, 3 and 4. Analyses rated as A1 are excellent; A2 or B1, good; A3, B2 or C1, fair; and the others poor.

Felspar is abundant at Mt. Franklin and at Mt. Anakie in loose basalt scoria, and is also found at many other points of eruption of the New Volcanic basalts. On the shores of Lake Purrumbete and other lakes of the Western District it is fairly common, and has been derived from bedded tuffs. It also occurs at Mt. Look-out (Aberfeldy) and other volcanic centres in Gippsland associated with the Older Volcanic basalt. It is found as colourless and transparent cleavage fragments, generally small but ranging up to about two inches long, as rounded lumps evidently partly absorbed by molten igneous rock, and occasionally as crystals more or less rounded. Howitt (2) described some specimens from Mt. Anakie as having albite and pericline twin lamellae, and he measured extinction angles as follows:—

P.	M.	Perpendicular to P & M.
+3°7'	+12° 30'	+10°0'
+3°3'	+12° 19'	+11°5'

Other examples since examined often resemble microcline in having twin lamellae in two directions, but extinction angles vary

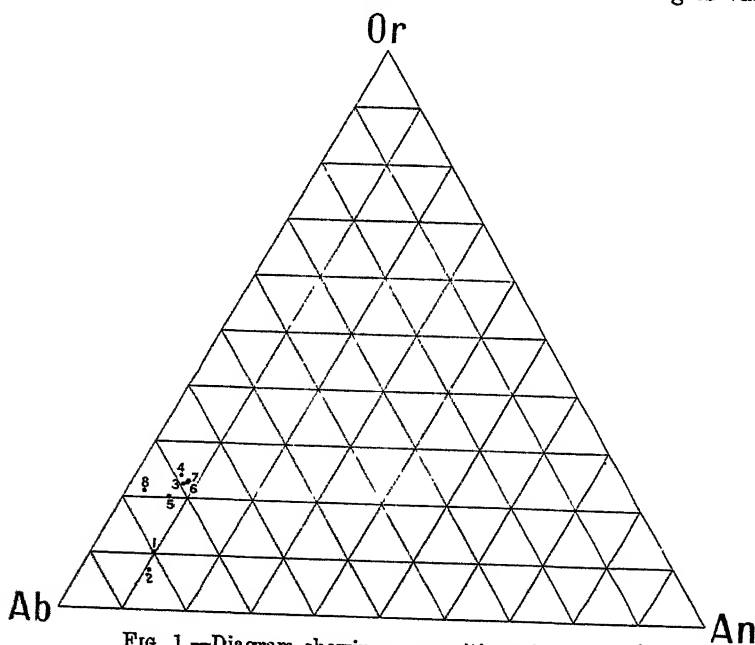


FIG. 1.—Diagram shewing composition of Felspars.
Numbers correspond with Analyses.

somewhat in different parts of the same specimen. A section parallel to (001) from an Aberfeldy specimen extinguished at 6°; this feldspar is twinned on the albite law. It contains a few minute vermiform intergrowths, probably quartz, and some minute specks too small for determination. It is quite clear and undecomposed.

The analyses and the triangular diagram show that all these feldspars are anorthoclases ranging from potash albite to potash oligoclase, and that they are very different from the feldspars entering into the composition of the associated basaltic rocks. Every analysis (except one which is rated as poor) gives an excess of SiO_2 and Al_2O_3 above the calculated amount required to combine with the alkalis. These substances may be in solid solution with the feldspar, or the quartz may be intergrown as indicated in the Aberfeldy feldspar mentioned above.

ANALYSES OF FERRO-MAGNESIAN MINERALS.

9			10			11		
	%	mol propn.		%	mol. propn.		%	mol propn.
SiO_2	- 49.00	- 0.8127	- 39.09	- 0.6483	- 41.53	- 0.6889		
Al_2O_3	- 8.66	- 0.0847	- 15.34	- 0.1500	- 0.95	- 0.0093		
Fe_2O_3	- 2.78	- 0.0174	- 12.43	- 0.0778	- nil.	- —		
FeO	- 6.52	- 0.0908	- 6.79	- 0.0945	- 9.02	- 0.1256		
MgO	- 14.53	- 0.3604	- 7.67	- 0.1902	- 48.02	- 1.1909		
CaO	- 15.64	- 0.2790	- 9.35	- 0.1668	- 0.31	- 0.0053		
Na_2O	- 1.12	- 0.0181	- 2.32	- 0.0374	- 0.14	- 0.0020		
K_2O	- 0.05	- 0.0005	- 1.51	- 0.0160	- 0.03	- 0.0003		
$\text{H}_2\text{O} +$	- 0.06	- 0.0028	- 0.91	- 0.0506	- 0.38	- 0.0211		
$\text{H}_2\text{O} -$	- 0.14	- —	- 0.09	- —	- 0.10	- —		
CO_2	- nil.	- —	- nil.	- —	- nil.	- —		
TiO_2	- 1.27	- 0.0158	- 4.76	- 0.0593	- tr.	- —		
P_2O_5	- nil.	- —	strong tr.	- —	- nil.	- —		
MnO	- 0.24	- 0.0034	- tr.	- —	- —	- —		
Li_2O	- nil.	- —	- nil.	- —	- —	- —		
SO_3	- tr.	- —	- tr.	- —	- nil.	- —		
NiO	- 0.04	- 0.0005	- —	- —	- —	- —		
CoO	- tr.	- —	- —	- —	- —	- —		
BaO	- nil.	- —	- —	- —	- —	- —		
S	- 0.13	- 0.0041	- —	- —	- —	- —		
Cr_2O_3	- 0.03	- 0.0002	- —	- —	- nil.	- —		
	100.21		100.26		100.48			
Rating	A1.I		A1.I		A1.I			

9. Augite, Mount Noorat, near Terang. Sp.gr. 3.342. Analyst, A. G. Hall.

10. Hornblende, Mount Anakie. Sp.gr. 3.32. Analyst, F. F. Field.
 11. Olivine, Mount Anakie. Granular material from an "olivine bomb." Analyst, F. F. Field.

Augite.

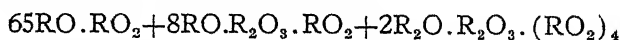
Only one analysis of augite has been made, and unfortunately none of the material (which consisted of a black cleavage fragment from Mt. Noorat) was kept for microscopical investigation. It is a type rich in alumina and alkalis and poor in lime. This is best shown by taking the maximum, minimum and average figures from the analyses of augites quoted by Iddings (3) and comparing them with those for the Noorat specimen.

			Al ₂ O ₃ (36 anal.)		CaO (36 anal.)		Na ₂ O (18 anal.)
Maximum	-	-	9.15	-	23.46	-	1.47
Minimum	-	-	2.82	-	15.98	-	tr.
Average	-	-	5.86	-	20.89	-	0.81
Noorat augite	-		8.66	-	15.64	-	1.12

Augites are considered to consist of various proportions of the molecules RO.RO₂, RO.R₂O₃.RO₂ and sometimes R₂O.R₂O₃ (RO₂)₄. On this basis the composition of the Noorat specimen works out as follows:—

Radiole	-	-	RO ₂	-	R ₂ O ₃	-	RO	-	R ₂ O
Mol. propn.	-	-	8285	-	1023	-	7341	-	214
R ₂ O.R ₂ O ₃ .4RO ₂	-		856	-	214	-	—	-	214
RO.R ₂ O ₃ .RO ₂	-	-	809	-	809	-	809	-	—
RO.RO ₂	-	-	6532	-	—	-	6532	-	—
Surplus	-	-	88	-	—	-	—	-	—

The molecular formula is therefore



and there is an excess by weight of 0.53% SiO₂ or 0.70% TiO₂.

Hornblende.

One good analysis of hornblende is also available. The material consisted of black cleavage fragments from Mt. Anakie. Examined microscopically the crushed mineral is a monoclinic amphibole, brown (burnt umber) in colour in very small fragments, the large being opaque. It is moderately pleochroic (brown to buff) and the extinction angle measured from the *c*-axis on cleavage fragments parallel to the *a*-axis is 9°. The analysis shows that it is rich in Al₂O₃ and alkalis, and poor in lime for this type of

mineral, as indicated by comparison with figures taken from Iddings's quoted analyses of hornblendes from igneous rocks.

		Al ₂ O ₃ (30 anal.)		CaO (30 anal.)		Na ₂ O (26 anal.)
Maximum	- -	17.36	-	13.03	-	3.18
Minimum	- -	1.50	-	9.25	-	0.37
Average	- -	10.69	-	11.62	-	1.67
Anakie hornblende		15.34		9.35		2.32

The calculation of the formula offers some difficulties. The hornblendes consist of some or all of the molecules RO.RO₂, R₂O.RO.2RO₂, R₂O.R₂O₃.2RO₂ and RO.R₂O₃.RO₂. The simple method used above in the case of augite is not applicable since no radicle is confined to a single molecule. Let w , x , y and z be the amounts of the above molecules, and a the amount of RO₂ in the whole of them. Then

$$\begin{aligned} w+2x+2y+z &= a \quad (\text{total RO}_2 \text{ required}) \\ x+y &= 1040 \quad (\text{total R}_2\text{O}) \\ y+z &= 2278 \quad (\text{total R}_2\text{O}_3) \\ w+x+z &= 4575 \quad (\text{total RO}) \end{aligned}$$

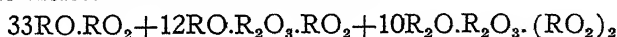
and from these equations

$$\begin{aligned} w &= 2a - 9973 \\ x &= 6655 - a \\ y &= a - 5615 \\ z &= 7893 - a \end{aligned}$$

The maximum value of a is therefore 6655 and the minimum 5616. It is reasonable to choose the maximum since this figure will give the least excess of RO₂. Then $x=0$. The composition now works out as follows:—

Radicle	- -	RO ₂	-	R ₂ O ₃	-	RO	-	RO ₂
Mol. propn.	- -	7076	-	2278	-	4575	-	1040
w RO.RO ₂	- -	3337	-	—	-	3337	-	—
y R ₂ O.R ₂ O ₃ .2RO ₂	-	2080	-	1040	-	—	-	1040
z RO.R ₂ O ₃ .RO ₂	-	1238	-	1238	-	1238	-	—
Surplus	- -	421	-	—	-	—	-	—

The molecular formula is therefore



and there is an excess by weight of 2.54% SiO₂ or 3.37% TiO₂.

The ejected felspar, augite and hornblende are, therefore, all types rich in alkalis, alumina, and silica, and poor in lime.

Olivine.

Olivine from points of eruption either forms small, well-defined crystals, or more commonly granular masses up to a foot or more

in diameter containing an admixture of other minerals. Greenish-yellow crystals about an eighth of an inch long, sp. gr. 3.486, were collected from the scoria on top of Mt. Terang. The crystal forms developed are (010), (001), (110), (120), (101), (011) and (021). The mineral was found to contain 15.80% FeO, from which its composition is estimated to be

Forsterite (Mg_2SiO_4) 77.57% by weight
 Fayalite (Fe_2SiO_4) 22.43%.

The analysed olivine from Mt. Anakie was picked out from the crushed granular nucleus of a volcanic bomb, and is yellowish-green in colour. Its calculated composition is

Forsterite, 86.76% by weight.
 Fayalite, 13.24%.

How the other oxides in this analysis are combined is difficult to picture, but possibly they form a basic feldspar.

Both olivines are rich in magnesia, and contain only about 10% of the fayalite molecule.

Magma.

Bowen (4) has shown experimentally that minerals rich in magnesia are the first to crystallise from a cooling magma containing the elements of diopside and the plagioclases, and that alkaline minerals appear at a late stage of cooling; also that in systems involving such mix-crystals as the olivines, the earlier crystals are enriched in magnesia. It therefore seems highly probable that the olivine was formed at an earlier stage in the history of the magma than the other minerals considered above and that its association with them is more or less fortuitous. The inference is that the original magma during the progress of cooling separated by some process of differentiation into two types, one a normal basalt and the other an alkali-gabbro; and that the feldspar, augite and hornblende discussed above come from the alkali-gabbro differentiate. This inference is supported by the facts that ejected blocks of essexite type occur in the basaltic tuffs of Lake Bullenmerri (5); that alkaline volcanic rocks of Tertiary age are found at Macedon (6 and 7); and that analcite basalts are plentiful in Gippsland.

If the alkaline magma be admitted, the distribution in Victoria of the minerals here considered indicates that it is widespread, and is at least as old as the Older Basalt. In contrast is the fact that typical alkaline volcanic rocks are comparatively rare. The explanation may be that the alkaline magma was relatively too viscous to flow to the surface with the same ease as the basalt. The fine-grained texture of the basalt, the infrequency of porphyritic crystals in it and the glassy nature of its quickly cooled portions show that it arrived at the surface in a completely fluid state; and the extent and thinness of the flows show that it was very mobile. On the other hand, the comparatively large size of the minerals

considered in this paper indicates long continued crystallization of the magma in which they originated; the alkaline volcanic rocks of Macedon are typically porphyritic; and it is known that alumina increases the viscosity of a "melt." It would therefore appear that the original magma separated into more and less alkaline portions before Tertiary volcanic action began. The basaltic portion remained highly mobile, and rose to the surface more easily than the alkaline, partly crystallized, more viscid portion, which in consequence seldom formed lava flows, though some of its constituents together with molten basalt were hurled by explosions from points of eruption. The anorthoclase basalts of the Macedon district and the analcite basalts of Gippsland may represent a less advanced stage of differentiation or the mixing of the two types of magma.

The magmatic differentiation suggested by the study of the ejected minerals agrees in general with the deductions made by Professors Skeats and Summers (7) as a result of their exhaustive study of the Macedon area; but it appears that the process began before the ejection of the Older Basalts of Gippsland and continued or was repeated until the end of the volcanic period.

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ART. VIII.—*Experimental Error of Field Trials in Australia.*

By H. C. FORSTER, B.Ag.Sc., and A. J. VASEY, B.Ag.Sc.
(Department of Agriculture, Melbourne).

[Read 18th October, 1927; issued separately 28th April, 1928.]

Introduction.

The question of the "Probable Error" in field trials is one which has in recent years come to the fore in connection with the work of experimental stations in Europe and America. It has sometimes been suggested that in Australia the water supply available in the soil for the crop is often the limiting factor to growth and seed production. This might lead to a more uniform growth, and thus the experimental error of plot observations might be thereby diminished. It seemed, therefore, worth while to investigate the matter fully, and with this end in view the classic experiment of Hall and Mercer was repeated at the State Research Farm, Werribee, Victoria, it being felt that such an investigation should lead to valuable results which would be a guide for the future in the "lay out" of the trial plots.

The experiment was undertaken to determine—

- (1) the variation in an apparently uniform acre of wheat as measured by the "Standard Deviation," and the "Probable Error" of 1/160th acre plots,
- (2) the optimum
 - (a) size,
 - (b) shape,
 - (c) number of plots necessary to reduce this error to a minimum.

Method.

During the season 1926-27, the North Railway Field at Werribee was planted with "Free Gallipoli" wheat, and it produced a fair average crop, which was, before harvest, expected to yield about 24 bushels to the acre. An acre of this was selected for the experiment, and many casual observers were agreed that as far as the eye could judge, it was an even area of wheat.

A preliminary survey was made on the 29th November, 1926, when it was observed that the drilling was somewhat irregular. There was one double-sown row in every stroke of the drill, and therefore it was decided to include two of these double-sown rows in each plot. Accordingly each plot was made 30 x 20 links, and the dimensions of the whole acre, 300 x 320 links, excluding

paths. Further it was found that near the western boundary of the acre, a strip a few yards wide had been damaged by cart-tracks. This was consequently excluded.

A straight row on the western side of the acre was taken as a base-line, and from this all measurements were set off. These allowed for the division of the acre into four quarters by means of two intersecting paths.

On account of the danger of shaking-out by storms before the harvesting of the whole area had been completed, an occurrence which would have wrecked the whole experiment, it was deemed advisable to mark out only one quarter-acre at a time. This was then harvested immediately. Owing to extremely favourable weather conditions during the harvesting period, such precautions proved unnecessary.

Along the boundaries of each quarter-acre pegs were put in corresponding to the corners of the outside plots. The boundaries of each $1/160$ th acre plot were then defined by stakes whose positions were obtained by sighting from the outside pegs. Paths were then cut in a N.-S. direction, dividing the quarter-acre into 5 strips of 8 plots each. These paths were 4 drill-rows wide, and were made by hand-cutting 2 rows on each side of the actual boundaries of the plot as defined by line and plumb-bob. As the bags for the reception of the produce from each plot had previously been marked, the crop cut in the formation of the paths was transferred immediately to the corresponding sack.

Cutting was commenced on the 22nd December with a single-horse mower fitted with a carrier-arrangement. The mower was driven in an E.-W. direction across the paths, thus cutting five plots. It was stopped in each pathway—specially cut for this purpose—to enable the crop cut from each plot to be bagged straight from the carrier. After four swathes of the mower, a strip of about one foot was left along the northern boundary of each plot. This was cut by hand, the exact boundary being defined by line and plumb-bob as before. Plots were then thoroughly gleaned for any heads that had been broken off, as well as any loose straws.

Before cutting, the plots were examined for the number of rows they contained, and for the presence of any disturbing factors. There were very few weeds. In a similar manner the other three quarter-acres were harvested, the bagged produce of the plots being carted and stored as the harvesting of each quarter-acre was completed. Field work was finished on the 7th January, 1927.

Thrashing was commenced on the 18th January. This was performed by means of a motor-stripper, which consisted of the drum and beaters of a typical Australian harvester, driven by a stationery engine mounted on the same under-carriage. After thrashing the wheat fed into the beaters, both straw and grain were delivered into a bin at the rear. Here the straw was collected, and later re-thrashed separately from the grain. The

grain was winnowed to an even sample, and weighed to the nearest ounce, which was considered the limit of the overall accuracy of the experiment. Thrashing was completed on the 27th January.

Results and Discussion.

TABLE 1.—*Plan and weights in ounces of grain harvested from 160 wheat plots.*

125 - 117 - 125 - 135 - 150	139 - 150 - 164 - 143 - - 157
121 - 135 - 123 - 147 - 147	130 - 141 - 154 - 144 - - 161
124 - 137 - 126 - 135 - 142	142 - 138 - 135 - 139 - - 136
125 - 134 - 127 - 130 - 144	133 - 141 - 147 - 142 - - 147
128 - 135 - 121 - 136 - 138	140 - 135 - 140 - 139 - - 139
132 - 127 - 118 - 134 - 135	137 - 137 - 138 - 127 - - 145
137 - 133 - 122 - 131 - 120	137 - 139 - 142 - 133 - - 148
141 - 128 - 130 - 126 - 119	149 - 143 - 132 - 133 - - 144
E	
123 - 123 - 119 - 120 - 111	139 - 152 - 142 - 140 - - 143
115 - 125 - 135 - 121 - 125	143 - 143 - 135 - 143 - - 146
121 - 120 - 133 - 132 - 128	144 - 133 - 127 - 137 - - 137
137 - 123 - 141 - 124 - 128	135 - 139 - 139 - 137 - - 142
127 - 131 - 136 - 121 - 135	135 - 133 - 135 - 133 - - 131
122 - 124 - 144 - 132 - 128	136 - 143 - 145 - 143 - - 142
122 - 108 - 141 - 143 - 125	139 - 148 - 150 - 152 - - 154
130 - 135 - 161 - 154 - 154	153 - 141 - 130 - 152 - - 161
	W
	Cart
	tracks
	N

Table 1 shows the yields of plots together with their position in the field. The yields varied from 108 to 164 ozs., the variation being 20.6% on either side of the mean. The frequency curve as shown in Figure 1 was obtained by grouping the yields into periods of 5 ounces each.

With the curve from the actual results is shown the normal curve of error calculated to fit the results. Owing to the small number of observations, the approximation of the actual curve (*vide* Figure 1) to the above is considered close enough to justify the conclusion that the material was homogeneous, and that the formulae applicable to such, may be used in this case.

A study of Table 1 shows that there is a definite rise in yield from East to West, while the variations from North to South are apparently irregular. The graph (Fig. 2) of the sum totals of the rows of plots, as set out in Table 2, verifies these conclusions.

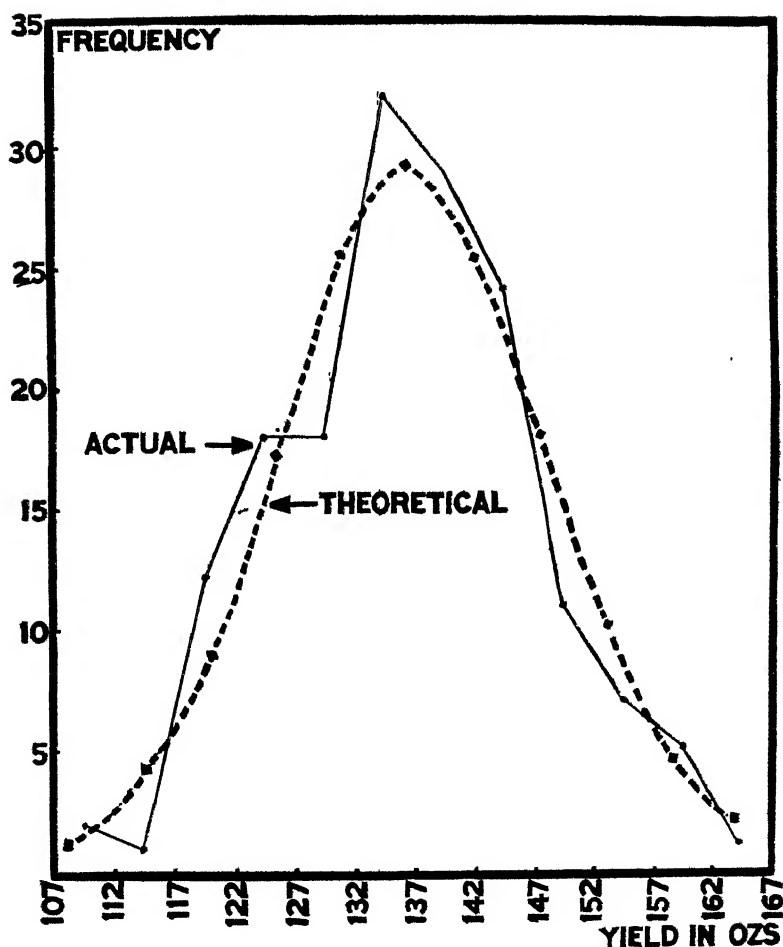


FIG. 1.—Frequency curves for 160 wheat plots.
(Actual and Theoretical).

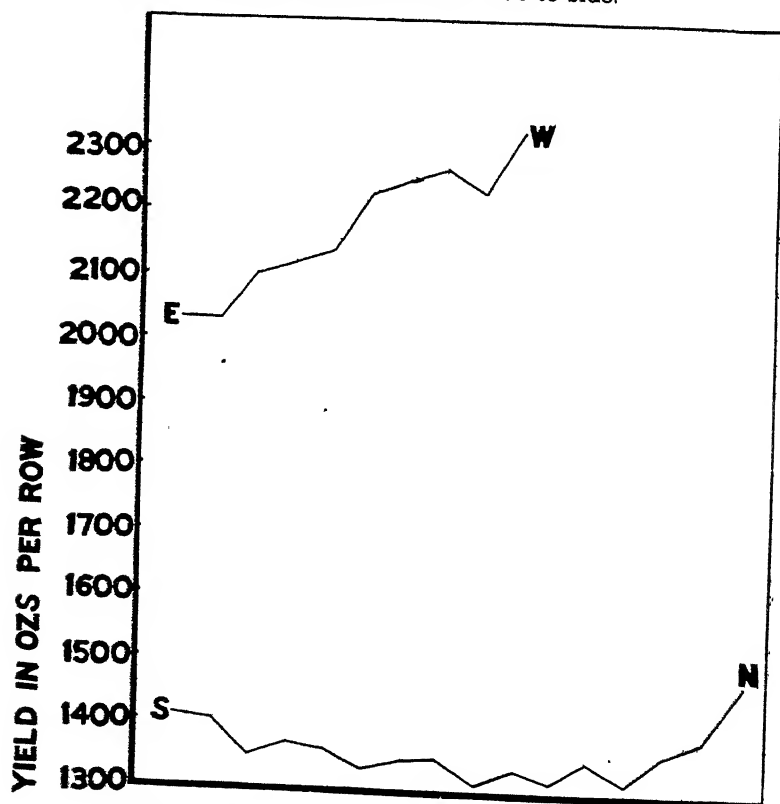
It is necessary to consider briefly these disturbing elements before proceeding to the main discussion and conclusions.

The presence of such a regular rise in the field under observation is a factor which has appeared in most investigations of this character. In their Mangold experiment, Hall and Mercer had a similar experience in a variation from North to South of 7.3%, which, after being observed and noted, was subsequently disregarded in the calculation of results. In this case, there is a variation from E.-W. of 6.9% on either side of the mean. The irregular variation from South to North is similarly 5.9%. Since

TABLE 2.—*Varying weight of rows of plot yields.*

South-North	East-West
1414 ozs.	2030 ozs.
1403 "	2035 "
1354 "	2102 "
1370 "	2121 "
1360 "	2138 "
1330 "	2231 "
1342 "	2256 "
1345 "	2264 "
1312 "	2287 "
1331 "	2333 "
1312 "	
1345 "	
1317 "	
1359 "	
1382 "	
1471 "	

these variations, viz. 6.9% from E.-W., and 5.9% from S.-N., are of approximately the same order, it is possible in a similar manner to disregard this regular variation from side to side.

FIG. 2.—*Varying weights of rows of plot yields.*

Hall and Mercer in their experiment measured each plot as a definite distance along a certain number of rows, thus taking area of crop as their unit. On account of the irregular drilling, it was impossible in this experiment to include a definite number of rows in each plot; therefore area of land was taken as the unit.

The examination of the number of drill rows showed a variation of from 33 to 35 rows per plot. This variation, 34 ± 1 , is of the order of 3%. On taking only those plots containing 34 rows, the yields varied from 115 to 164 ounces, a range of approximately 18% on either side of the mean. Thus the normal variation due to chance is far greater than the difference that could be produced by such variation in the number of rows, and this may therefore be grouped with these chance errors. A more accurate comparison may be drawn between the Standard Deviation of all the plots ($S.D.=10.9 \pm 0.41$ ozs.), and that from those containing the same number of rows (34), $S.D.=11.9 \pm 0.58$ ozs.). These two figures are of the same order. Now, since this S.D. is a measure of the variance of the plot yields, the above assumption is confirmed.

The Variation in an Apparently Uniform Acre of Wheat
as measured by the Standard Deviation and the Probable
Error of 1/160th acre plots.

TABLE 3.—*Calculation of the Standard Deviation.*

Group	Frequency		Deviation from Arbitrary Mean		x^2	fx	fx^2			
	f	x	x	x						
107-111	-	2	-	-5	-	25	-	-10	-	50
112-116	-	1	-	-4	-	16	-	-4	-	16
117-121	-	12	-	-3	-	9	-	-36	-	108
122-126	-	18	-	-2	-	4	-	-36	-	72
127-131	-	18	-	-1	-	1	-	-18	-	18
132-136	-	32	-	0	-	0	-	0	-	0
137-141	-	29	-	1	-	1	-	29	-	29
142-146	-	24	-	2	-	4	-	48	-	96
147-151	-	11	-	3	-	9	-	33	-	99
152-156	-	7	-	4	-	16	-	28	-	112
157-161	-	5	-	5	-	25	-	25	-	125
162-166	-	1	-	6	-	36	-	6	-	36
Totals		160		—		—		65		761

It may be calculated by the usual formulae that the mean yield of the 1/160th acre plots is 136.5 ± 7.3 ozs., i.e., there is an even chance that the yield from any one plot will be between 143.8 ozs.

and 129.2 ozs. Further that if a comparison were made between a pair of 1/160th acre plots of two different varieties of wheat on similar land to that found here, any differences between yields of less than 23.3 ozs. (17.7% of the mean), would not be significant.

Optimum Size of Plot.

In order to determine the optimum size of plot for purposes of yield trials, i.e. that size of plot which will give the least variation from the mean, it was necessary to compare the S.D. of different sizes of plots. By the grouping of adjacent plots, the yields from areas of different sizes have been obtained. The method of grouping is indicated by the accompanying dimensions in Table 3.

TABLE 4.—*The Standard Deviation (%) of Plots of Various Sizes.*

Size of Plot	No. of Plots	Dimensions	Standard (%) Deviation
1/160th	- 160	- 30 × 20 lks.	- 8.0%
1/80th	- 80	- 30 × 40 „	- 7.0
1/40th	- 40	- 60 × 40 „	- 5.8
1/20th	- 20	- 80 × 60 „	- 5.2
1/10th	- 10	- 80 × 120 „	- 4.6

N.B.—The small number of results in the two latter cases detracts somewhat from the reliability of the figures 5.2 and 4.6% respectively.

From the above table and the following graph, it will be noted that the S.D. (%) falls rapidly from 8.0% in the case of the 1/160th acre plots to 5.8% at the 1/40th acre plots. Further increase in size up to 1/10th acre only reduces this quantity to 4.6%. Now, since the larger the area, the greater the difficulty in obtaining an "apparently uniform" area of soil, it follows that little is to be gained by increasing the size of plot for yield trials above 1/40th of an acre.

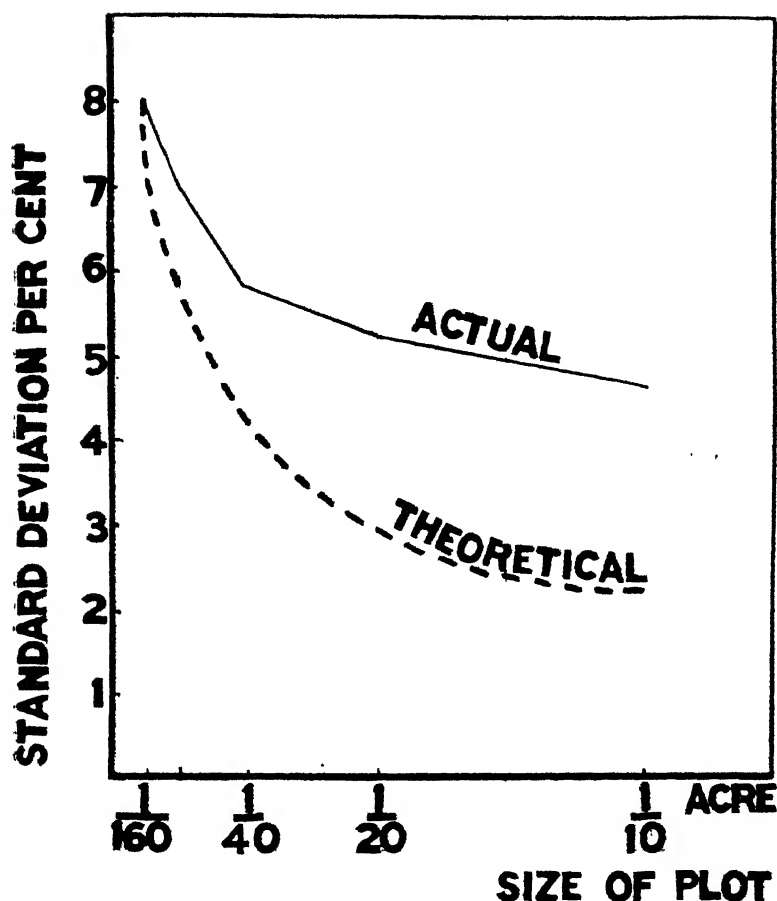


FIG. 3.—*Actual and Theoretical Curves of the Standard Deviation of Plots of Various Sizes.*

N.B.—The theoretical curve is obtained by the division of the S.D. of the 1/160th acre plots by the square root of the number of the original number of small plots combined in each grouping.

Optimum Shape of Plot.

It is generally considered that a long narrow plot is more desirable for field-scale work than a short square plot, and the following table tends to establish this belief.

TABLE 5.—*Standard Deviation of Plots of Various Shapes.*

Size of Plot	No. of Plots	Dimensions	Standard % Deviation
1/40th ac.	40	60 × 40 lks.	5·8%
1/40th „	32	20 × 120 „	5·0
1/20th „	20	80 × 60 „	5·2
1/20th „	16	20 × 120 „	3·7

It is important to note that on account of the gradual increase in yield from east to west, plots with their axis in a north to south direction cannot be used in the above comparison.

Optimum Number of Replications desirable.

Having determined the size and shape most desirable from a practical standpoint, it was necessary to find the number of replications required for a working minimum of error. The S.D. was then calculated for two scattered 1/20th acre plots, four scattered 1/40th acre plots, etc. Maximum scattering was obtained by entering the yields of the various sized plots on slips of paper, which were later drawn from a bowl, and thus the various sets of pairs, fours, eights, etc., were made up.

TABLE 6.—*Standard Deviation of 1/10th acre plots obtained by random grouping of various numbers of units.*

No. of Units in 1/10 ac. plot	No. of observations	Standard Deviation %
1	1	4·6%
2	2	4·0
4	4	3·18
8	8	2·46
16	16	2·3

N.B.—Only a low reliability can be placed on the figure 4·6, due to the small number of results.

From this it would appear that a greater number of replications than four or five is not warranted, as the small increase in accuracy so obtained would entail a great amount of extra work.

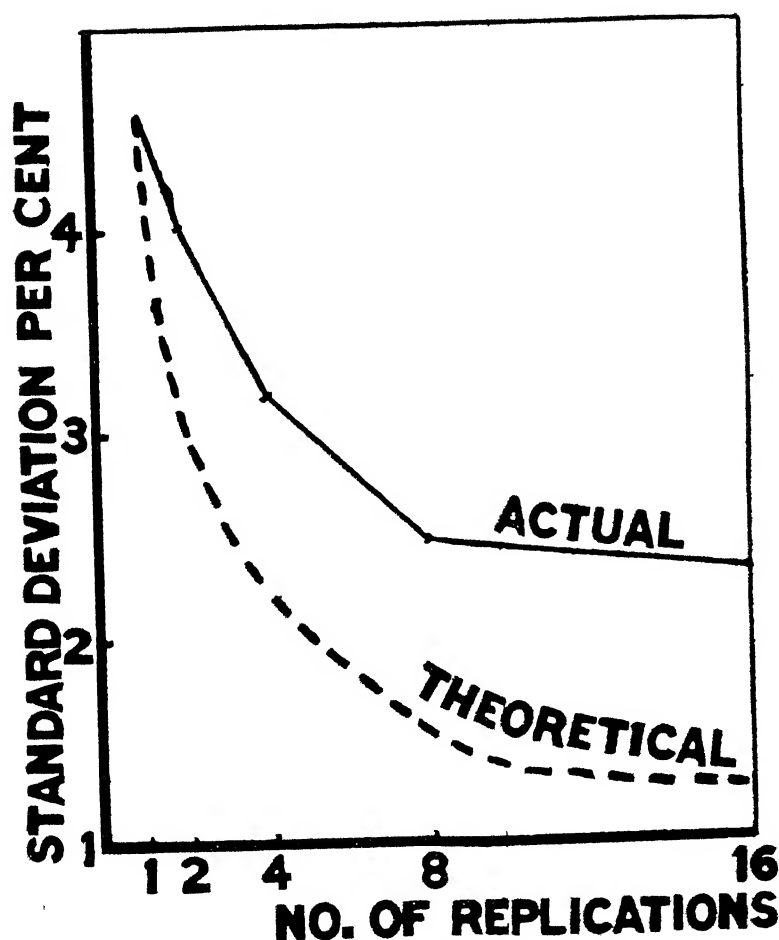


FIG. 4.—Relation between the Standard Deviation and the Number of Replications.
(Actual and Theoretical).

N.B.—The theoretical value is obtained by the division of the S.D. of 1/10th acre plots by the square root of the number of units into which it was divided.

Conclusions.

While the small number of observations necessarily detracts from the accuracy of some of the results, the following conclusions seem to be justified, supporting, as they do, most of the previous work overseas.

- (1) That in this field experiment, there are two types of error—
 - (a) casual, due to small chance errors in harvesting technique, uneven seeding, manuring, hare-tracks, etc. These may be so gradual as to be inappreciable to the eye.
 - (b) more regular errors, due to marked soil variations, climate, etc.
- (2) That the casual error attaching to a single plot decreases with the increasing size of plot, but the more systematic error of soil variation becomes more important as the plot increases in size.
- (3) The optimum size for field trials for cereals under conditions such as these, is 1/40th acre.
- (4) That there would appear to be grounds for the belief that a long narrow plot is the more desirable for field trials.
- (5) That the error attaching to a 1/40th acre plot is diminished to a working minimum by a replication of five times in any one series.

It is absolutely essential that these results be applied with caution. They are only of value for the conditions which prevailed during the period of the experiment, on the particular soil on which the experiment was conducted. Thus in the first place they will apply only to areas of crop in which *the eye is unable to detect any serious lack of uniformity*. If a field, used for yield trials, contained areas in which the crop was locally affected owing to disease, extra-heavy rain or some other exceptional circumstance, there would be no reason for expecting that the statistical results obtained in the Werribee work would hold good in such an area.

In the second place, with different climatic conditions the results might be different, but the marked similarity between the results at Werribee and at Rothamsted suggests that this is not likely to be a very serious source of trouble.

Finally, the authors wish gratefully to acknowledge all assistance received. The experiment itself was undertaken under the direction of the Department of Agriculture, Melbourne, at the suggestion of Mr. H. A. Mullett, Superintendent of Agriculture.

They are also greatly indebted to Professor S. M. Wadham for his many suggestions and helpful criticism of this report.

The facility and accuracy obtained in the field work would have been impossible but for the assistance of Mr. A. Morgan, B.Ag.Sc., and Messrs. Pescott and Skene, students in Agriculture in the University of Melbourne.

ART. IX.—*Contributions to the Flora of Australia, No. 34.**
Additions to the Flora of the Northern Territory and
Locality Records.

By

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and

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[Read 8th December, 1927; issued separately 28th April, 1928.]

The records made in this paper are mainly the result of a revision of the collection of Northern Territory plants made by the Horn Expedition in 1894. This collection is housed in the Tate Herbarium at the University of Adelaide, and we have here to acknowledge our gratitude to Professor Osborn for making this material available to us.

Many of the species have not been previously recorded either in the report of the Horn Expedition or in the Flora of the Northern Territory, and other records add considerably to the range of species already known without definite locality from Northern Australia, and recorded in the Melbourne National Herbarium Census.

This paper is a further step in the collection of material for a complete Flora of the Northern Territory.

GRAMINEAE.

Eriochloa punctata Hamilton.

Swallow Creek, Gidia Creek, and Opossum Waterhole, R.

Tate, May, 1894, (labelled *E. polystachya* H. B. et K.).

Panicum effusum R.Br.

Tennant's Creek, R. Tate, 1894.

P. reversum F.v.M.

Finke River, R. Tate, 1894.

Setaria glauca (L.) Beauv.

Palmerston, Arnheim's Land, M. Holtze, 1882.

S. verticillata (L.) Beauv.

Opossum Waterhole, R. Tate, 1894.

Alopecurus geniculatus L.

Barrow Creek, R. Tate, 1894.

*No. 33 in *Proc. Roy. Soc. Vic.*, n.s., xxxix. (2), p. 154.

Eriachne ovata Nees var. *pallida* Benth.

MacDonnell Ranges, R. Tate, 1894.

Triraphis danthonioides F.v.M.

Gill's Range, R. Tate, 1894.

This is the first definite locality recorded for this species in the Northern Territory.

Chloris divaricata R.Br.

Finke River, R. Tate, 1894 (labelled *C. acicularis*).

Fimbristylis Neilsonii F.v.M.

MacDonnell Ranges, Rev. Kempe, 1883.

Scirpus americanus Pers.

Illara Water, R. Tate, 1894 (labelled *S. pungens*).

This species had not been previously recorded for the Northern Territory.

CENTROLEPIDACEAE.

Centrolepis polygyna (R.Br.) Hieron.

South of the MacDonnell Ranges, R. Tate, 1894.

POLYGONACEAE.

Polygonum serrulatum Lag.

Finke River, R. Tate, 1894.

CHENOPODIACEAE.

Chenopodium cristatum F.v.M.

Ilpilla Gorge, R. Tate, 1894.

Atriplex campanulatum Benth.

On the sandhills south of the MacDonnell Ranges, R. Tate, 1894. This species has not been previously recorded for the Northern Territory.

A. fissivalve F.v.M.

Near Elizabeth Creek, — Giles.

This species has not been previously recorded for the Northern Territory.

A. limbatum Benth.

Finke River, R. Tate, 1894.

Bassia convexula R. H. Anders. (= *B. echinopsila* F.v.M.).

The Goyder and Ilpilla Gorge, R. Tate, 1894.

B. eriacantha (F.v.M.) R. H. Anders.

This species has not been previously recorded for the Northern Territory.

Kochia Georgei Diels.

Mt. Olga, W. H. Tietkens, 1899.

K. villosa L. var. *enchylaenoides* J. M. Black.

Charlotte Waters, R. Tate, 1894.

- Threlkeldia inchoata* J. M. Black.
Adminga Creek, R. Tate, 1894.
Arthrocnemum halocnemoides Nees.
Finke River, R. Tate, 1894.

AMARANTACEAE.

- Trichinum arthrolasium* F.v.M.
MacDonnell Ranges, R. Tate, 1894.
T. helipteroides F.v.M.
Ilpilla, Barrow Creek, R. Tate, 1894.
T. helipteroides F.v.M. var. *minor* J. M. Black.
Finke River, R. Tate, 1894.
T. nobile L. (= *Ptilotus nobilis* (L.) F.v.M.).
Mt. Sonder, MacDonnell Ranges, R. Tate, 1894.
T. parvifolium F.v.M. (= *Ptilotus parvifolius* F.v.M.).
Crown Point, Finke River, R. Tate, 1894.
This is the first definite locality recorded for this species in the Northern Territory.
Amarantus Mitchelli Benth.
On the sandhills south of the MacDonnell Ranges, R. Tate, 1894.
This species has not been previously recorded for the Northern Territory.
Gomphrema affinis F.v.M.
Crocker Island, R. Tate (No. 60), March, 1883; Pine Creek, MacDonnell Ranges, R. Tate, 1894.
G. Brownii Moq.
Finke River, Rev. Kempe, 1882; Mt. Sonder, R. Tate, 1894.
G. parvifolia Benth.
Mt. Norris Bay, R. Tate (No. 79), March, 1883; Pine Creek and Barrow Creek, R. Tate, 1894.

AIZOACEAE.

- Trianthema crystallina* Vahl. var. *clavata* J. M. Black.
Throughout the MacDonnell Ranges, R. Tate, 1894.

PORTULACAEAE.

- Portulaca filifolia* F.v.M.
Stuart's Pass, MacDonnell Ranges, R. Tate, 1894.
P. oleracea L. var. *grandifolia* Benth.
On the sandhills of the MacDonnell Ranges, R. Tate, 1894.
Calandrinia polyandra (Hook.) Benth.
Finke River, R. Tate, 1894.
This is the first definite locality recorded for this species in the Northern Territory.

- C. pusilla* L. (= *C. volubilis* Benth.).
 MacDonnell Ranges, Rev. Kempe, 1883.
 This species has not been previously recorded for the Northern Territory.
- C. remota* J. M. Black.
 Charlotte Waters, Baron von Mueller.

CRUCIFERAE.

- Menkea australis* Lehm.
 South of the MacDonnell Ranges, R. Tate, 1894.
- M. sphaerocarpa*, F.v.M.
 Mt. Olga, Rev. Kempe, 1883.

CRASSULACEAE.

- Crassula bonariensis* (D.C.) Cambess.
 Finke River, Rev. Kempe, 1883; (labelled *Tillaea purpurata* Hook.).
- C. colorata* (Nees) Ostenf.
 MacDonnell Ranges, R. Tate, 1894.

LEGUMINOSAE.

- Acacia Bynoeana* Benth. (= *A. Wilhelmiana* F.v.M.).
 Along the west end of Lake Amadeus, W. H. Tietkens, 1889.
- A. Cambagei* Baker.
 The Goyder, Swallow Creek, and on the slopes of Mt. Daniel, R. Tate 1894 (labelled *A. homalophylla* Cunn.).
- A. coriacea* D.C.
 MacDonnell Ranges, R. Tate, 1894.
- A. ligulata* A. Cunn.
 West of the MacDonnell Ranges, W. H. Tietkens, 1889.
- Cassia Sturtii* R.Br. var. *involucrata* J. M. Black.
 Stuart's Pass, MacDonnell Ranges, R. Tate, 1894.
- Bauhinia Leichardtii* F.v.M. var. *cinerascens*.
 MacDonnell Ranges, C. A. Winnecke, 1883.
- Isotropis Winneckiana* F.v.M.
 MacDonnell Ranges, C. A. Winnecke, 1883.
- Crotalaria unifoliata* Benth.
 Cameron's Well, Central Australia, R. Tate, 1894.
- Indigofera saxicola* F.v.M.
 Yam Creek, R. Tate (No. 7), 1883.
- Swainsona Burkei* F.v.M. var. *parviflora*.
 Near Mt. Sonder, R. Tate, 1894.
- S. canescens* F.v.M. var. *Horniana* Tate.
 Glen Helen Gorge, R. Tate, 1894 (labelled *S. Horniana*).
- S. stipularis* F.v.M.
 Common in the scrub near the Goyder, W. H. Tietkens, 1889.

ZYGOPHYLLACEAE.

- Zygophyllum Billardieri* D.C. (= *Z. ammophyllum* F.v.M.).
 Finke River at Idracowrie, R. Tate, 1894.
Z. compressum J. M. Black.
 Sonder's Range, R. Tate, 1894.
Tribulus minutus Leich.
 Ayer's Rock, MacDonnell Ranges, W. H. Tietkens, 1889.

POLYGALACEAE.

- Polygala orbicularis* Benth.
 Port Darwin, R. Tate (No. 95), 1883.

STACKHOUSIACEAE.

- Macgregoria racimigera* F.v.M.
 MacDonnell Ranges, C. A. Winnecke, 1883; Mt. Gillen and
 North of Alice Springs, R. Tate, 1894.
 This is the first definite locality recorded for this species in
 the Northern Territory.

TILIACEAE.

- Corchorus vermicularis* F.v.M. (= *Scorpioides simplicifolia* Ewart
 and Petrie, 1926).
 Wycliffe, A. J. Ewart, 1924.
 This curious plant is only recorded from one locality in
 Bentham's Flora, and it is sparsely distributed in the
 Northern Territory, usually near to river banks or on
 flood-plains. In North-West Australia it has recently
 appeared in many localities from Derby to Fitzroy
 Crossing and Leopold, mostly on grazed river areas
 after floods, in some cases being now the dominant vege-
 tation over acres of ground. Apparently it is a native
 plant whose spread is favoured by grazing; sheep, cattle
 and horses usually avoid it, and even goats appear to
 eat it only sparingly.

STERCULIACEAE.

- Melhamia incana* Heyne (= *Sideria reverta* Ewart and Petrie,
 1926).
 Taylor's Well, A. J. Ewart, 1924. This is the first record
 of this plant in the interior of Northern Australia. The
 suppressed genus "*Sideria*" was placed under the Mal-
 vacaceae.
Ruelingia hermanniaefolia Steetz.
 Near the Finke River, Rev. Kempe, 1882; Watson Hills, W.
 H. Tietkens, 1889. (Labelled *Commersonia Kempeana*:
 F.v.M.).

DILLENACEAE.

Pachynema sphenandrum F.v.M.

Near Yam Creek, R. Tate, 1894.

This is the first definite locality recorded for this species in the Northern Territory.

LYTHRACEAE.

Rotala occultifolia Koch var. *Leichardtii* Koch.

West of the MacDonnell Ranges, W. H. Tietkens, 1889;
Deering Creek, R. Tate, 1894.

This is the first definite locality recorded for this species in the Northern Territory.

MYRTACEAE.

Micromyrtus ciliata J. M. Black (= *Thryptomene flavifolia* F.v.M.).

Along the south side of Gill's Range, R. Tate, 1894.

HALORRHAGIDACEAE.

Loudonia Roei Schlechtd.

On the sandhills south of Gill's Range, R. Tate, 1894.

BORAGINACEAE.

Heliotropium heteranthum F.v.M.

Near Lake MacDonald, Central Australia, W. H. Tietkens,
June, 1889.

H. tenuifolium R.Br.

MacDonnell Ranges, R. Tate, 1894.

CONVOLVULACEAE.

Ipomoea heterophylla Schrank.

Port Darwin, R. Tate, (No. 50), 1883.

I. lonchophylla J. M. Black.

Swallow Creek, R. Tate, 1894 (labelled *I. heterophylla*).

SCROPHULARIACEAE.

Striga curviflora Benth.

MacDonnell Ranges, W. H. Tietkens, 1889.

S. hirsuta, Benth.

Port Darwin, R. Tate (No. 99), 1883.

This species has not been previously recorded for the Northern Territory.

ACANTHACEAE.

Ruellia bracteata R.Br.

Yam Creek, R. Tate (No. 29), 1883.

MYOPORACEAE.

Myoporum deserti A. Cunn.

South of the MacDonnell Ranges, W. H. Tietkens, 1889.

M. montanum R.Br.

MacDonnell Ranges, R. Tate, 1894 (labelled *M. Dampieri*).

Eremophila Elderi F.v.M.

James's Range, R. Tate, 1894.

E. Latrobei F.v.M. var. *Tietkensii* (= *E. Tietkensii* F.v.M.).

On the south side of Gill's Range, R. Tate, 1894.

* *E. neglecta* J. M. Black.

At Yellow Cliffs, near Charlotte Waters, R. Tate, 1894.

VERBENACEAE.

Newcastlia cephalantha F.v.M.

Finke River, R. Tate, 1894.

RUBIACEAE.

Oldenlandia elatinoides F.v.M.

Deering Creek and Haast's Bluff, MacDonnell Ranges, R. Tate, 1894.

This species has not been previously recorded for the Northern Territory.

GOODENIACEAE.

Scaveola ovalifolia R.Br. var. *parviflora*.

Mt. Sonder, Illawarta and Idracowra, R. Tate, 1894. This is the first record of this variety in the Northern Territory.

COMPOSITAE.

Vittadinia brachycomoides F.v.M.

Throughout the MacDonnell Ranges, R. Tate, 1894.

Calotis cuneifolia R.Br.

In the mulga scrub at Glen Edith, R. Tate, 1894 (labelled *C. dentrix*).

This species has not been previously recorded for the Northern Territory.

C. scabiosifolia F.v.M.

Finke River, R. Tate, 1894.

Helichrysum bracteatum Willd.

Finke River, Rev. Kempe, 1883 (labelled *H. lucidum* Henck.).

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ART. X.—*Fossil Plants of the Stony Creek Basin.*

By REUBEN T. PATTON, B.Sc., M.F.

(With Plate VIII.)

[Read 8th December, 1927; issued separately 7th June, 1928].

The geology of the Stony Creek Basin, Daylesford, has been the subject of many papers, the last of which being that by Orr (1). In this basin is a thick deposit of black ligneous clay, the origin of which is a matter of doubt. Although in places the deposit contains a large amount of plant material, yet owing to its lack of any definite lamination it is very difficult to secure unbroken specimens. This applies particularly to the leaves of the genus *Eucalyptus*, which occur abundantly. Small fragments of what is apparently fern material are present, but the identification is difficult. One fern appears to be *Pteridium aquilinum*, which is at present world wide. Another specimen has large broad frond segments with large orbicular sori, characters which are identical with the living species *Polypodium pustulatum*. The veining of the leaves of the Eucalypt leaves can be very distinctly made out in fresh material. No complete leaves were obtained. The veining is of two distinct types: one has the veins very oblique and the other has the veins set at an angle of about 45° . The oblique veining occurs among others in the living species *E. amygdalina*, and the other type is seen in the living species *E. viminalis*. Both these species occur living in the area under discussion. The veining of *E. amygdalina* is very variable, so that it is quite possible that the leaves all belong to the same species. The leaves are all comparatively narrow and falcate, and about 4 to 6 inches long. It is quite probable that the fossil leaves belong to the existing species. Besides the leaves, however, there are woody masses which are very soft and cheesy in consistency. The material is very soft and, therefore, difficult to section, but when dry it is very brittle and fractures like coal.

Microscopically it is seen that the cell walls have been enormously swollen, so much so that in most parts the cell cavity has been obliterated. This swelling of the walls has also caused the bordered pits to a very large extent to disappear, and other characters are also very much affected. This makes the identification very difficult. However, it is easily seen that the wood is of gymnospermous origin. The annual rings are very distinct, and are also very broad. Approximately the spring and the autumn wood are about equal in breadth. The summer wood is very dense, and owing to the swelling of the walls the lumen is completely obliterated. The spring wood is very open, and comparatively thin walled. This portion of the ring is very much distorted. At first sight it would appear that the wood had been subject to strong pressure in a radial direction, but the nature of

the deposit in which it occurs does not favour this suggestion. The distortion is entirely due to the swelling of the walls. In cross section no resin canals nor resin cells can be observed, but it is quite possible that even if the latter were present in the summer wood they would not be observed. In longitudinal radial section it is seen that the bordered pits, which are but rarely preserved, were arranged in single rows. The medullary rays are homogenous. The pits connecting the medullary rays with the tracheides are large, broad, elliptical and simple. These, too, have been largely obliterated by the swelling of the walls. This character had been observed in some fossil wood sent by Baron von Mueller to Schenk (2, pp. 872-4), and named by the latter *Phyllocladus Muelleri*. These large pits had already been noted in the living species *Phyllocladus trichomanoides*, which is endemic to New Zealand. These pits also occur in the Tasmanian species, *P. rhomboidalis*. This is also an endemic species. These pits are,

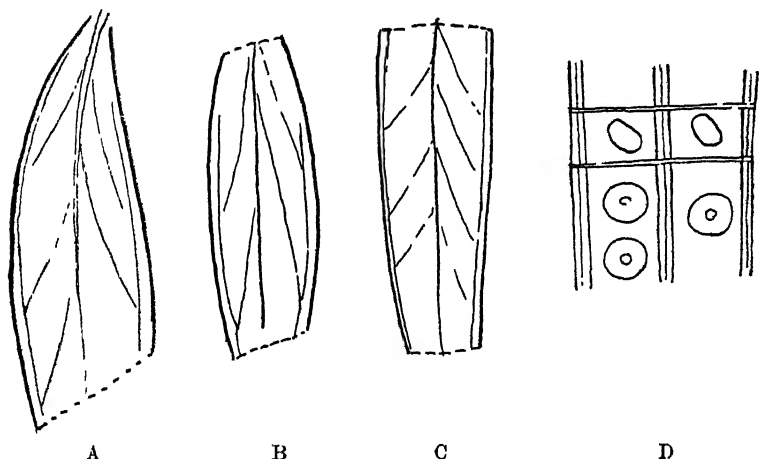


FIG. 1.—A, B and C leaves of *Eucalyptus* spp.
D Radial section of woody material shewing uniseriate bordered pits of the medullary rays.

however, not confined to the genus *Phyllocladus*, for they also occur in the two endemic Tasmanian species, *Dacrydium Franklini* and *Microcachrys tetragona*. The last genus is endemic to Tasmania, and is monotypic. The other two genera in which the large elliptical pits occur, are, however, very widely distributed. *Phyllocladus* occurs in Tasmania, New Zealand, New Guinea, Borneo and the Philippine Islands. *Dacrydium* occurs in Tasmania, New Zealand, Fiji Is., New Caledonia, New Guinea, Borneo, Philippine Is., Malay and Chile. From the distribution of the existing species it is seen that these two genera range over a very wide area, and it is therefore very surprising that, while these two genera are found on the south, east and north of Australia,

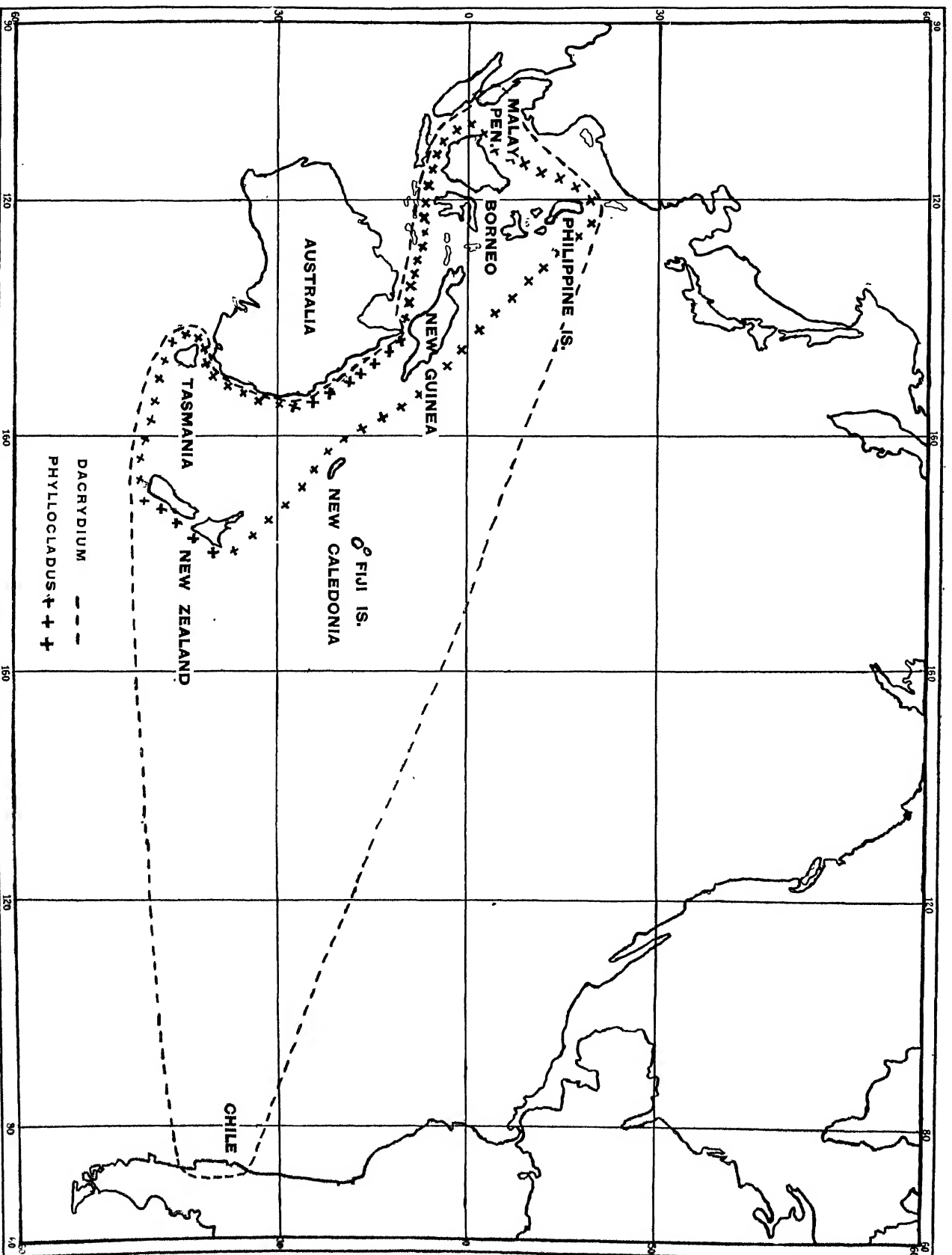
they are nowhere found at present on the mainland itself. The two genera, *Phyllocladus* and *Dacrydium*, as far as their Tasmanian species are concerned, are so very similar as regards their wood anatomy that it is impossible to separate them. It is therefore impossible to say in which genus this fossil wood should be placed. The longitudinal tangential section does not show any definite characters, and this is also a feature of the Tasmanian species mentioned above. Similar fossil wood has been obtained from the Malakoff Reef at Ballarat, and also from the Langi Logan Mine at Ararat. From the distribution of the fossil wood, therefore, it is apparent that somewhere about the Newer Basaltic period at least one of the above genera was present in Australia itself. The disappearance of the genus from the mainland has been probably due to secular changes of climate since basaltic times. The three genera mentioned are found in the wetter areas of Tasmania, and therefore it is most probable that similar conditions previously existed in those parts of Victoria where the fossils have been found. The presence of *Polypodium* sp. also indicates a wet habitat. *Polypodium* to-day exists as an epiphyte on tree-ferns, and other arboreal vegetation in the moist gullies of the State. This further supports the suggestion that the climate was formerly moister than it is to-day. The distribution of the species *Eucalyptus amygdalina*, *E. viminalis* and *Pteridium aquilinum* is not controlled by climatic but by soil conditions. All these three are found in the wettest areas as well as in the comparatively dry regions. The area where the fossils have been found has, therefore, apparently become progressively drier, and therefore moisture loving species have, so to speak, been driven out.

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EXPLANATION OF PLATE VIII.

Distribution of the genera *Phyllocladus* and *Dacrydium*.



Distribution of *Phyllocladus* and *Dacrydium*.

ART. XI.—*The Staurograptus Bed of Victoria.*

By W. J. HARRIS, M.A., and R. A. KEBLE.

(With Plate IX.)

[Read 8th December, 1927; issued separately 7th June, 1928.]

Messrs. W. J. Harris and W. Crawford recently found some dendroid graptolites of considerable importance to Victorian Ordovician stratigraphy, in a band of slate on the bank of a creek 3 miles north east of Romsey. The band contains the genus *Staurograptus*, and we regard it as being very near the base of the Lower Ordovician. The band (approximately 27 chains, N.18°W. from the south-west corner of Allot. 26, Parish of Springfield, on a water reserve), is of hard, black slate intercalated with bands of chert, quartzite, and altered sandstone. A note on Quarter Sheet 5 S.E. refers to the outcrop as "black shales." The strike is almost north and south and dip 86° west. Easterly up the creek is an outcrop of quartz-porphyr¹. Still further east shales, mudstones and sandstones occur, lithologically similar to those outcropping in typical Silurian areas.²

Only two graptolite genera, viz. *Staurograptus* and *Dictyonema*, have been recognised, in both cases preserved as films on the bedding planes of the slate, but in profusion. *Staurograptus* is a new record for Victoria; *Dictyonema* has been found at several localities, more particularly at Taylor's Quarry, 5 miles to the north. There *D. macgillivrayi* T. S. Hall, *D. pulchellum* T. S. Hall, and *D. grande* T. S. Hall, occur with *Bryograptus*, *Clonograptus*, *Tetragraptus*, etc.

Genus *Staurograptus* Emmons.

STAUROGRAPTUS DIFFISSUS, sp. nov.

(Plate IX., Figs. 1-5.)

Polypary broadly conical to saucer shaped; usually vertically compressed. Sicular long, conical, suspended by a long nema; no primary disc observed.

The primary theca grows beyond the aperture of the sicular; the polypary begins with four or more branches.

Polypary small, in cyathiform aspect less than 1.5 cm. wide distally, in vertically compressed aspect (apparently less mature forms) not exceeding 1 cm. It develops by dichotomy to approxi-

1.—This is shown on the Quarter Sheet as "greenstone," and was probably presumed to belong to the diabases of which the hills to the north are largely composed. It is an acid dyke similar to those found further south.

2.—Professor Skeats, however, has described these as Heathcoteian eastwards up to the Basalt junction. Pan-Pacific Sci. Congress, Australia, Melb. Handbook, p. 134, 1923; reprinted in Proc. Pan-Pac. Sci. Cong., Aust. 1923, ii., p. 1667, 1925.

mately 16 branches of the fourth order; none of our forms seems to have developed further.

Branches slender, about 0.25 mm. wide, all the branches slightly flexuous, branching at irregular intervals. In the horizontally compressed polypary the branches of the third order diverge at an average angle of 45° .

Thecae number from 20 to 25 in 10 mm., in contact for one-third of their length, outer wall straight or slightly concave, apertural margin slightly concave. Ventral margin makes, with the axis of branch, an angle of about 40° .

Remarks.—The nema of the mature forms is about 7.0 mm. in length, and is often split, giving the appearance of a double nema, bifurcating at different distances from the sicula. In one instance the strands of the nema are twisted around each other below the sicula, but reunite and apparently form a single tube at a still lower level. Except as regards size, the vertically compressed polypary bears a considerable resemblance to *S. dichotomous* Emmons. It differs, however, from that species in the angles of bifurcation and the details of its thecae. In the cyathiform aspect the typical nema is readily recognised.

Associates.—*Dictyonema scitulum*, sp. nov., *D. campanulatum*, sp. nov., and Crustaceae.

Genus *Dictyonema* Eichwald.

DICTYONEMA CAMPANULATUM, sp. nov.

(Plate X., Figs. 6-13.)

Polypary cyathiform, flabelliformly compressed in mature specimens, attaining a length of approximately 1.2 cm. and a width of 1.5 cm. Branches irregularly disposed, somewhat flexuous; outside branches convex to the axis of the polypary proximally, approximately straight distally, inside branches flexuous throughout. Bifurcations fairly frequent. Branches from 0.3 to 0.4 mm. wide of increasing width, 10 with interspaces in a width of 10 mm., space between the branches more than the width of the branches. Stout transverse dissepiments 1.0 mm. to 2.0 mm. apart, which, with the adjacent branches enclose an irregularly shaped interspace.

Thecae 12-14 in 10 mm., acutely dentiform.

Sicula about 0.7 mm. long with long attenuated nema.

Remarks.—The material on which this description is based cannot be regarded as ideal. Nevertheless there is little doubt regarding the distinctness of *D. campanulatum* from any other form known to us.

Some specimens (Pl. IX., Figs. 7, 8, 10, 12, 13) show curious double or triple nemas, hair-like filaments, one of which occasionally ends in a small triangular body suggestive of a peduncular attachment.

Associates.—*Staurograptus diffissus*, sp. nov., and *D. scitulum*, sp. nov. Crustaceae.

DICTYONEMA SCITULUM, sp. nov.

(Plate IX., Figs. 14-19.)

Polypary cyathiform, flabelliformly compressed, in mature specimens attaining a length of 2 cm., a width distally of about 2 cm. (included in an angle of 85°).

Branches nearly parallel, regularly disposed, outer ones slightly concave to axis of polypary proximally, and straight distally, inner ones straight throughout. Bifurcations infrequent. Branches 0.4 mm. (0.4-0.5 mm.) wide, of constant width, 13-14 occupying (with interspaces) a width of 10 mm. The spaces between the branches is somewhat less than the width of the branches. Comparatively stout transverse dissepiments, from 0.7 mm. to 1.5 mm. wide, connect the branches and these with the branches enclose a subrectangular interspace. Thecae 14-17 in 10 mm. distally. Thecal apertures thickened and acutely dentiform.

Sicula 1 mm. long.

Remarks.—The type specimen, although preserved as a film, exhibits some of the characteristics revealed by Wiman (1), Bulman (2) and others in their work of isolation of specimens in relief from matrices with dilute acids.

Two types of thecae may be recognised, the thecae and "gonangia" of Wiman (1). The latter arise from opposite sides of the former and throughout their short length appear to be disposed in alternately right and left hand spirals, their apertures being opposed. The apertures are visibly thickened. An attempt was made to trace some plan of arrangement of the cell groups about the branches, but, other than that indicated, unsuccessfully.

The dissepiments are straight bars connecting adjacent branches and show no evidence of fusion midway. An apertural process, very similar to that described by Ruedemann in regard to the thecae of *D. furciferum* (3, p. 607), extends from the flattened aperture of the "gonangium" and impinges on the dorsal part of the adjoining branch.

There is little doubt that *D. scitulum*, sp. nov. is closely related to *D. furciferum*, but unfortunately the thecae of the type specimen are not clearly enough shown to ascertain whether the difference is varietal or specific. On the other hand, Ruedemann (3, pl. iii., f. 11) has only figured a portion of a polypary, and until better material is forthcoming, it has been thought desirable, on account of its stratigraphical importance in Victoria, to give *D. scitulum* specific rank.

Associates.—*Staurograptus diffissus*, sp. nov. and *D. campulatum*, sp. nov. Crustaceae.

Correlation of Fauna.

The importance of the Springfield association to the Victorian Ordovician sequence lies in the facts that it is the oldest graptolite

fauna yet discovered in Australia, and is comparable with the oldest but one of the graptolite associations of America and Europe. The graptolite succession is generally alike in all parts of the world and the forms described in this contribution are so closely related to those found in similar associations elsewhere that there is little doubt that the Springfield slates are very near to the base of the Ordovician. Making world-wide comparisons, stratigraphically above them should occur a fauna equivalent to that of the American Deep Kill Zone III, containing *Clonograptus flexilis* and *Tetragraptus* (4, p. 130); such a position and association is held by the Taylor's Quarry slates east of Lancefield (5, p. 175).

If conditions were suitable to its preservation and it is accessible, a bed containing exclusively a *Dictyonema* allied to *D. flabeliforme* Eich. should yet be found in Victoria stratigraphically below the Springfield slates. This bed in other parts was formerly regarded as marking the closing stage of the Cambrian, but latterly both in American and Europe, it has been recognised as introducing the extensive Ordovician transgression. Such is probably the case in Victoria, for stratigraphically above the Springfield slates we have a very comprehensive suite of Lower Ordovician graptolites which have been zoned and subzoned, while, apparently, stratigraphically below them a little east of their strike some distance north we have the Cambrian *Dinesus* trilobite fauna. It is probably in this direction that the missing bed will be found.

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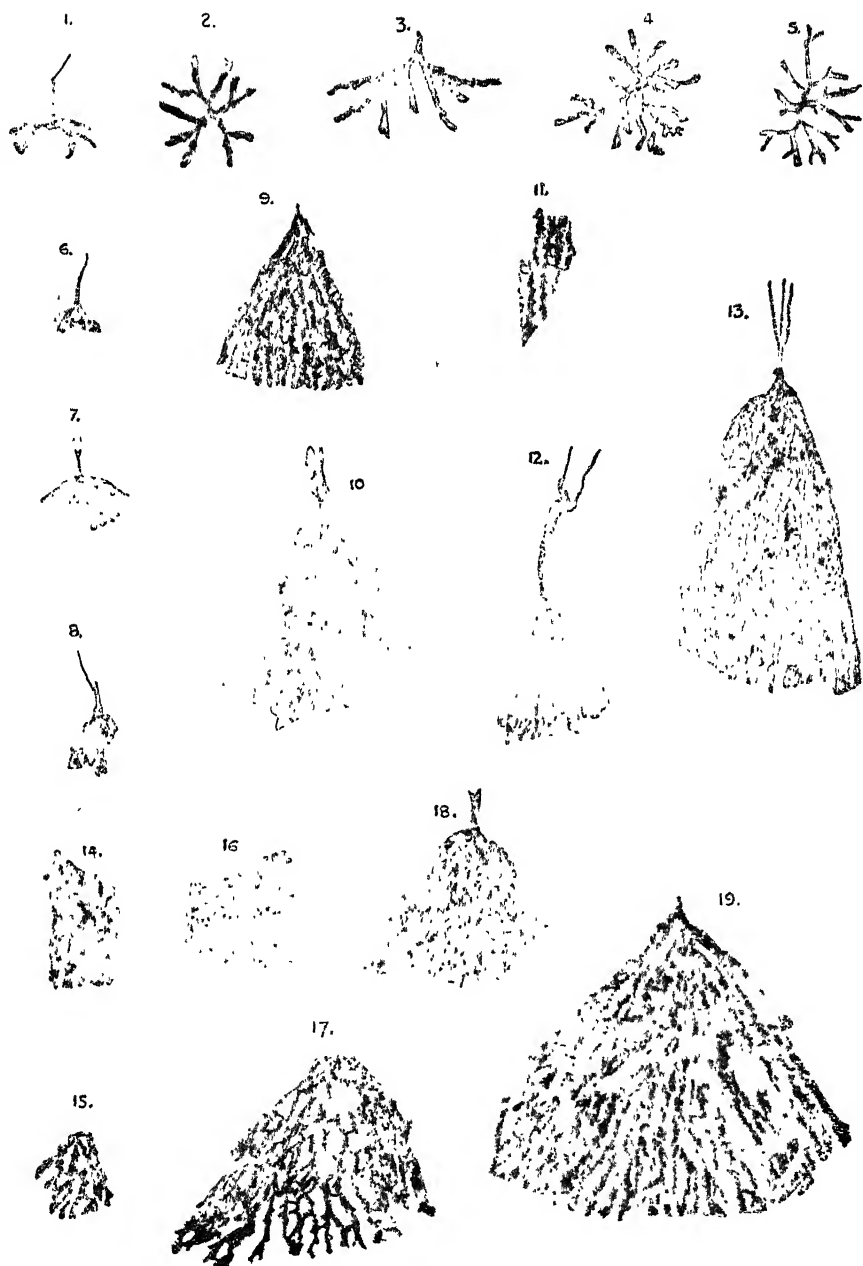
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EXPLANATION OF PLATE IX.

All Figures $\times 2.6$.

Figs. 1-5.—*Staurograptus diffissus*, sp. nov.

1. Young polypary showing sicula and nema. Paratype.
2. Polypary vertically compressed. Paratype.
3. Polypary laterally compressed. Paratype.
4. Polypary vertically compressed. Paratype.
5. Polypary vertically compressed. Holotype.



Figs. 6-13.—*Dictyonema campamulatum*, sp. nov.

6. Young polypary, with single nema. Paratype.
7. Young polypary with divided nema. Holotype.
8. Proximal portion of polypary, showing divided nema. Paratype.
9. Polypary showing typical form of polypary. Paratype.
10. Polypary, distorted, showing divided and attachment suggestive of peduncular appendage. Paratype.
11. Portion of polypary showing dissepiments. Paratype.
12. Proximal portion of polypary showing divided nema. Paratype.
13. Complete polypary with tripartite nema. Paratype.

Figs. 14-19.—*D. scitulum*, sp. nov.

14. Portion of polypary showing interspaces and dissepiments. Paratype.
15. Imperfect polypary showing interspaces. Paratype.
16. Portion of mature polypary showing transverse dissepiments. Paratype.
17. Distorted polypary. Paratype.
18. Polypary. Paratype.
19. Complete polypary. Holotype.

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Osborne, Prof. W. A., M.B., B.Ch., D.Sc., University, Carlton, N.3.	1910
Patton, R. T., B.Sc., M.F., Hartley-ave., Caulfield, S.E.8	1922
Payne, Prof. H., M.Inst.C.E., M.I.Mech E., University, Carlton, N.3.	1910
Penfold, Dr. W. J., M.B., Alfred Hospital, Commercial- road, Prahran, S.1.	1923
Petrie, A. H. K., B.Sc., University, Carlton, N.3	1925
Picken, D. K., M.A., Ormond College, Parkville, N.3 . . .	1916
Piesse, E. L., 43 Sackville-street, Kew, E.4	1921
Pratt, Ambrose, M.A., 376 Flinders-lane, Melbourne, C.1	1918
Quayle, E. T., B.A., 27 Collins-street, Essendon, W.5 . .	1920
Rae, F. J., B.Sc., B.Ag.Sc., Botanic Gardens, South Yarra, S.E.1.	1927
Reid, J. S., 498 Punt-road, South Yarra, S.E.1	1924
Rivett, Dr. A. C. D., M.A., D.Sc., Council for Scientific and Industrial Research, 314 Albert-street, East Mel- bourne, C.2.	1911
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Shephard, John, "Norwood," South-road, Brighton Beach, S.5.	1894
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Skeats, Prof. E. W., D.Sc., A.R.C.Sc., F.G.S., University, Carlton, N.3.	1905

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Summers, Associate Prof. H. S., D.Sc., University, Carlton, N.3.	1902
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Jones, Miss K. A. Gilman, Church of England Girls' Gram- mar School, Anderson-street, S. Yarra, S.E.1.		1922
Jutson, J. T., B.Sc., LL.B., "Darlington," 9 Ivanhoe-par- ade, Ivanhoe, N.21.	9	1902
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Melhuish, T. D'A., M.Sc., Adelaide Chemical and Fertilizer Co., Currie-street, Adelaide		1919
Mollison, Miss E., M.Sc., Royal-crescent, Camberwell, E.6.		1915
Moore, F. E., O.B.E., Chief Electrical Engineer's Branch, P.M.G.'s Department, Treasury Gardens, Mel- bourne, C.2.		1920
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Nicholson, Miss Margaret G., 59 Murray-street, Elstern- wick, S.4.		1920
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Pretty, R. B., M.Sc., Technical School, Wonthaggi, Vic.		1922
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Sharman, P. J., M.Sc., "Glenalvie," 9 Daphne-street, Canterbury, E.7.	1916
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Stillman, Miss E. G., B.Sc., "Taiyuan," 5 Grange-road, East Kew, E.4.	1919
Sutton, C. S., M.B., B.S., Education Department, Melbourne, C.2.	1908
Thomas, R. G., B.Ag.Sc., C/o Dr. Thomas. Northam, W.A.	1922
Thompson, Mrs. G. R., 26 Fawkner-street, St. Kilda, S.2	1922
Thorn, Wm., 37 Chrystobel-crescent, Hawthorn, E.2	1907
Traill, J. C., B.A., B.C.E., 630 St. Kilda-road, Melbourne, S.C.3.	1903
Treloar, H. M., Meteorological Offices, Melbourne, C.1 . .	1922
Trüdinger, W., 27 Gerald-street, Murrumbeena, S.E.9 . .	1918
Turner, A. H., M.Sc., Natural Philosophy Dept., University, Carlton, N.3.	1927
Turner, A. W., M.V.Sc., Veterinary School, Parkville, N.2.	1925
Wilcock, E. L., B.Sc., Dookie College, Dookie, Vic. . . .	1925
Williamson, H. B., F.L.S., "The Grange," 231 Waverley-road, East Malvern, S.E.5.	1919
Wilson, F. E., F.E.S., 22 Ferncroft-avenue, E. Malvern, S.E.5.	1921
Wilson, Major H. W., O.B.E., M.C., C.de G., B.Sc., 630 Inkerman-road, Caulfield, S.E.7.	1923
Withers, R. B., 10 Nicholson-street, Coburg, N.13. . . .	1926
Woodward, J. H., Queen's Buildings, 1 Rathdown street, Carlton, N.3.	1903

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[PART II. PUBLISHED 14th JUNE, 1928.]

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ART. I.—*Additions to the List of Australian Sea-Grasses.*

By C. H. OSTENFELD
(Copenhagen, Denmark).

(Communicated by Professor A. J. Ewart.)

[Read 10th April, 1930; issued separately 30th August, 1930.]

The following are additions to the list of Australian Sea Grasses (*These Proc.*, n.s., xlii (1), p. 1, 1929.)

Both *Diplanthera uninervis* and *Halophila spinulosa* (♂) have been found in W. Australia, at Carnarvon (1914, Herb. Copenhagen), which adds two more sea-grasses to the flora of W. Australia.

Cymodocea antarctica reaches in W. Australia at least as far north as Carnarvon.

I use this opportunity to add some new records which are due to the Danish Oceanographical Expedition on "Dana," 1929; viz:—

Cymodocea isoetifolia. Queensland: Brisbane.

Cymodocea rotundata. Queensland: Brisbane; Thursday Island. These records corroborate the somewhat uncertain record from Port Denison.

Zostera capricorni. Queensland: Brisbane. New South Wales: Newcastle; Lake Macquarie; Swansea.

Halophila ovalis. Queensland: Brisbane. New South Wales: Newcastle; Lake Macquarie; Botany Bay.

Collectors of Sea Grasses are requested to send any doubtful material to Dr. Ostensfeld, University, Copenhagen, for identification.

ART. II.—*New Formicidae, with Notes on some Little-known Species.*

By J. CLARK, F.L.S.

(Entomologist to the National Museum of Victoria, Melbourne.)

[Read 12th June, 1930; issued separately 30th August, 1930.]

The following pages contain the descriptions of fourteen new species, and the female of a previously described species.

A new genus, *Eubothroponera*, has been erected to contain three species which cannot satisfactorily be placed elsewhere. It is certainly close to *Bothroponera* Mayr.

Owing to the confusion which has always surrounded the ants collected by the members of the Horn Expedition and described by W. F. Kirby (Horn Expedition, i, suppl., pp. 203-207, 1896), it has been considered advisable to review the types in the National Museum collection. The identifications and descriptions are worthless, and none of the species are recorded by Emery in the *Genera Insectorum*. This is not to be wondered at, as it is impossible to determine anything from the descriptions given, and even with the types at hand it is difficult to make them agree. There appears to be five valid species among the material. These, with the exception of *Iridomyrmex flavipes*, have been redescribed. Forel's description of *I. rostrinotus* (= *I. flavipes* Kirby) is too complete to warrant further detail.

EUSPHINCTUS (NOTHOSPHINCTUS) BRUNNICORNIS, n. sp.

(Text-fig. 1, No. 1.)

Worker.—Length, 3.5—4.5 mm.

Yellow. Mandibles and funiculus, except the apical segment, brown.

Shining. Finely and densely punctate throughout.

Hair yellow, short and suberect, longer and more numerous on the apical segments of the gaster. Pubescence very fine, short, particularly on the antennae and legs.

Head one fourth longer than broad, as broad in front as behind, the occipital border concave, the sides feebly convex. Frontal carinae erect, truncate behind. Clypeus very short, with a blunt translucent tooth-like projection at the middle in front. Cheeks not, or very feebly, carinate. No trace of eyes or ocelli. Antennae short and robust, scapes not extending beyond the middle of the head; segments one to ten of the funiculus broader than long, the apical as long as the four preceding together. Mandibles large and triangular, furnished with twelve to fourteen teeth. Thorax one and three-quarter times longer than broad, without traces of sutures, feebly constricted in the mesonotal region, posterior

border of the epinotum feebly margined. Epinotal declivity abrupt, concave below, submarginate on the sides above; there is a blunt, tooth-like projection at each side below. Node as broad as long, slightly broader behind than in front, the anterior border straight, the sides and posterior border feebly convex; in profile as high as long, almost dome shaped; there is a broad, blunt, tooth-like projection on the ventral surface in front. Postpetiole almost one and a half times broader than long, broader behind than in front, the sides feebly convex. There is a deep and wide constriction between each of the segments of the gaster, all the segments broader than long. Pygidium truncate, flattened above, with a row of short, sharp spines on each side. Legs short and stout.

Habitat.—Western Australia: Collie (J. Clark).

Near *E. (N.) silaceus* Clark, from which it is readily distinguished by the somewhat shorter thorax, longer node and broader postpetiole, as well as by the colour of the mandibles and antennae.

PHYRACACES CLARUS, n. sp.

(Text-fig. 1, No. 2.)

Worker.—Length, 9—10 mm.

Bright castaneous. Antennae and tarsi darker. Eyes, ocelli, margins of the thorax and node black.

Shining. Densely and microscopically punctate throughout, slightly coarser on the front of the head than elsewhere. Lower half of the sides of the thorax finely rugose.

Hair yellow, long and erect, pointed, abundant throughout, particularly on the apical segments of the gaster, shorter on the antennae and legs. Pubescence very fine and adpressed, confined to the antennae and legs.

Head as long as broad, the occipital border almost straight, the sides convex. Frontal carinae erect, truncate and confluent behind. Carinae of the cheeks short, extending back level with the frontal carinae. Clypeus short, broadly rounded and feebly produced in front. Eyes large, almost globular, placed at the middle of the sides. Three large prominent ocelli. Scapes extending to the anterior ocellus; second segment of the funiculus fully one-third longer than the first, apical barely as long as the two preceding together. Mandibles triangular, finely denticulate, abruptly bent at their base. Thorax one and three-quarter times longer than broad, constricted at the mesonotal region, with faint traces of sutures. Pronotum convex and subbordered in front, strongly bordered and convex on the sides, the border terminates at the suture. Mesonotum not margined. Epinotum strongly convex and margined on the sides, the posterior border feebly convex and strongly margined. The declivity short and steep, submarginate on the sides. Petiole broader than long, much broader behind than in front, the anterior border concave, submarginate, the sides

strongly convex and marginate, the anterior angles sharp, the posterior angles produced as broad translucent teeth, directed outward and curved inward. There is only a feeble indication of a tooth on the ventral surface, near the middle. Postpetiole fully one-third broader than long, much broader behind than in front, the anterior border straight, marginate, the sides strongly convex, the anterior two-thirds submarginate. A deep and wide constriction between the postpetiole and gaster, the latter broader than long. Legs long and slender, hind coxae without a lamella behind.

Female.—Length, 10–12 mm.

Similar to the worker, but larger and winged. The pilosity is much more abundant. Parapsidal furrows strongly impressed. Mayrian furrows not defined. Wings hyaline, all the veins in front of the cubitus obsolete.

Male.—Length, 8 mm.

Colour and pilosity similar to the worker.

Shining. Head, pronotum, scutellum and epinotum finely and densely rugose. Mesonotum, node, postpetiole and gaster smooth with large, scattered, piligerous punctures.

Head broader than long, strongly convex behind. Frontal carinae erect, truncate but not confluent behind. Clypeus short, broadly rounded. Eyes large and convex, occupying almost half the sides. Ocelli large and convex. Scapes of the antennae extending to the anterior ocellus; second segment of the funiculus one third longer than the first. Mandibles large and triangular, edentate. Pronotum short, just visible from above, broadly convex. Mesonotum large, as broad as long, strongly arched in front, straight behind, mayrian and parapsidal furrows not indicated. Scutellum dome shaped, slightly broader than long. Epinotum broader than long, the posterior border margined; in profile the declivity straight, the sides margined. Node as long as broad, the anterior border straight, the sides and posterior border convex. Postpetiole as broad as long, almost three times broader behind than in front. First segment of the gaster one-fourth broader than long, broadest behind. Genitalia retracted. Legs long and slender.

Habitat.—Western Australia: Cannington (D. L. Serventy); Mundaring, Kalamunda and National Park (J. Clark).

This species comes nearest to *P. constricta* Clark, but may be distinguished by its smaller size and more robust thorax. In *P. constricta* the sides of the declivity are margined.

PHYRACACES FLAMMEUS, n. sp.

(Text-fig. 1, No. 3.)

Worker.—Length, 6.5 mm.

Red. Eyes and margins of the head, thorax and node black.

Shining. Mandibles punctate. Front of the face finely rugose, the rest of the head, thorax, node and gaster with isolated, shallow, piligerous punctures.

Hair yellow, long and suberect, abundant throughout, particularly on the apical segments of the gaster. Pubescence not apparent.

Head as broad as long, broader behind than in front, the occipital border and sides feebly convex, the angles rounded and margined; the margin extends from the inferior posterior corner to within one-third of its length from the posterior border of the eyes; this carina is continued on the under surface, and is the same length as the one above. Frontal carinae erect, truncate and confluent behind, with a distinct longitudinal carina between them. Clypeus very short and rounded. Eyes moderately large and convex, placed at the middle of the sides. No ocelli. A moderately strong carina on the cheek extending to the anterior third of the eyes, strongly bent inward behind the middle. Scapes extending to the posterior fourth of the head, gradually thickened to their apex; apical segment of the funiculus barely as long as the two preceding segments together. Mandibles triangular, the external border concave in the middle, the inner border edentate. Thorax one and one-half times longer than broad, the sutures feebly indicated. Pronotum feebly convex in front and on the sides, the angles sharp, strongly marginate. The posterior border of the epinotum almost straight, the sides convex; in profile the declivity straight and at an obtuse angle, the sides marginate. The pronotum is sharply margined vertically. Node one fourth broader than long, much broader in front than behind, the anterior border straight, strongly marginate, the sides strongly convex and marginate, the posterior corners produced as broad sharp teeth, directed upward and backward; in profile there is a broad bifid tooth in front below, directed backward. Postpetiole one fourth broader than long, the anterior border straight, or feebly concave, the sides strongly convex and margined. First segment of the gaster fully one fourth broader than long. Legs long and slender. Coxae of the hind pair with a broad translucent lamina on top behind.

Female.—Length, 6.5—7 mm.

Closely resembles the worker, differing only in larger size, the ocelli well developed, and the sutures of the thorax more strongly impressed. The pilosity is a little longer and more abundant.

Habitat.—Western Australia: Lesmurdie Falls (J. Clark).

This species comes nearest to *P. brevicollis* Clark, but is readily distinguished by its smaller size and more slender form.

PHYRACACES FLAVESCENS, n. sp.

(Text-fig. 1, No. 4.)

Worker.—Length, 3.8—4.3 mm.

Reddish yellow. Eyes and margins of the thorax and node black.

Shining. Head very finely and densely reticulate-punctate. Mandibles smooth, with some large scattered punctures. Thorax, node and postpetiole reticulate-punctate as on the head, remainder of the gaster superficially reticulate.

Hair yellow, long and erect, abundant throughout, very short and adpressed on the antennae and legs.

Head slightly longer than broad, as broad in front as behind, the occipital border straight, the sides convex. Frontal carinae erect, truncate and confluent behind. Clypeus short and rounded. Eyes large, moderately convex, placed at the middle of the sides. No ocelli. Carina of the cheeks extending to and touching the anterior third of the eyes, bent inward and branched at the middle, one portion extending to the frontal carina above the antennal fovea. Scapes extending to the posterior third of the head, gradually thickened to their apex; first segment of the funiculus one-fourth longer than the second, the apical as long as the three preceding segments together. Mandibles triangular, abruptly bent near the base, the external border concave at the middle, the inner border sharp, edentate. Thorax fully one and three quarter times longer than broad, without traces of sutures. Strongly constricted at the mesonotal region, the pronotum and epinotum of equal width. All four sides of the dorsum strongly marginate. Anterior border of the pronotum feebly convex, the angles sharp; in profile a sharp carina extending downward from the anterior angle. Posterior border of the epinotum convex; in profile the declivity abrupt and concave, marginate on the sides. Petiole broader than long, slightly broader behind than in front, the anterior border concave, the sides feebly convex, the posterior angles produced backward and inward as sharp, translucent teeth. The anterior border and sides marginate. Postpetiole slightly broader than long, convex in front and on the sides. First segment of the gaster much broader than long. Pygidium truncate, feebly margined, with a row of short bristles on each side. Legs long and slender, the posterior coxae with a large translucent lamina on top behind.

Female.—Length, 4.5—5 mm.

Very similar to the worker, but larger and more robust. Ocelli well developed. Mesonotum without mayrian furrows, parapsidal furrows well developed. Wings hyaline, with a brownish tinge, all the veins in front of the cubitus obsolete.

Habitat.—Western Australia: Eradna (J. Clark).

Near *P. newmani* Clark, from which it is distinguished by the colour, sculpture and more slender form, as well as by the form of the node.

Subfamily PONERINAE.

ACANTHOPONERA NIGRA, n. sp.

Worker.—Length, 2.7—3 mm.

Black. Mandibles brown. Scares and tarsi blackish brown.

Head, thorax and node opaque. Mandibles coarsely punctate. Head finely, longitudinally, striate-rugose on the middle, more reticulate-punctate on the sides. Pronotum finely reticulate-punctate. Mesonotum, epinotum and node and postpetiole more coarsely so. Declivity and gaster finely and densely punctate.

Hair reddish, long and erect, abundant throughout, shorter and suberect on the antennae and legs. Pubescence reddish, rather long and coarse, particularly on the gaster.

Head longer than broad, as broad in front as behind, the occipital border straight, the sides parallel, feebly convex, the angles rounded. Frontal carinae short, not as long as their distance apart, overhanging the antennal insertions in front. Clypeus convex above, the anterior border broadly convex. There is a strong carina extending from the anterior border of the clypeus to the occipital border. Eyes convex, placed at the posterior two-thirds of the head. Scapes extending slightly beyond the hind margin of the eyes; first segment of the funiculus three times longer than the second, the others subequal to the apical, which is longer than the two preceding together. Mandibles triangular, armed with five or six sharp teeth. Thorax one and a half times longer than broad. Pronotum one and two-third times broader than long, convex in front and on the sides. Suture between the mesonotum and epinotum very feebly defined. Mesonotum almost twice as long as broad. Epinotum fully twice as broad as long, the posterior border strongly concave, the angles produced. Declivity concave, with a distinct median furrow below, margined above and on the sides. Node one and two-third times broader than long, the anterior border and sides strongly convex, posterior border straight, or very feebly convex; in profile twice as high as long, parallel, the anterior, posterior and dorsal faces straight, the angles feebly rounded. There is a long, strong tooth in the middle of the under surface. This is continued in front, by a translucent membrane, as a plate-like projection. Postpetiole slightly broader than long, strongly convex in front and on the sides. There is a strong constriction between the postpetiole and first segment of the gaster, the latter slightly broader than long. Legs short and stout.

Habitat.—Victoria: Mt. William, Grampians (J. Clark).

The colour and pilosity separate this from the other known species.

EUPONERA (*TRACHYMESOPUS*) *PACHYNODA*, n. sp.

(Text-fig. 1, No. 5.)

Worker.—Length, 5 mm.

Castaneous. Densely and finely reticulate-punctate, more coarsely so on the gaster. Mandibles coarsely punctate.

Hair yellow, erect, long and abundant throughout, particularly on the apical segments of the gaster. Pubescence yellow, long

and adpressed on the head, thorax and node, much longer and more abundant on the gaster, but not hiding the sculpture, shorter on the antennae and legs.

Head longer than broad, as broad in front as behind, the occipital border concave, the sides convex. Frontal carinae short, twice as long as broad, flattened, overhanging the antennal insertions, separated by a very fine groove. Clypeus short, convex, broadly rounded in front. Eyes very minute, placed in front of the anterior third of the sides. Scapes extending beyond the occipital border by barely their thickness; first segment of the funiculus almost twice as long as the second, the others subequal to the apical, which is as long as the two preceding segments together. Thorax twice as long as broad. Pronotum broader than long, convex in front and on the sides. Mesonotum broader than long, strongly convex in front, feebly so behind. Epinotum longer than broad, convex in front, the sides parallel, the posterior border concave; in profile the dorsum straight longitudinally, the declivity convex, the sides feebly bordered. Node massive, one-third broader than long, strongly convex in front and on the sides, the posterior border straight; in profile almost one-third higher than long, parallel, the anterior and posterior faces straight, the dorsum feebly convex. There is a long tooth on the middle of the ventral surface, directed backward. Postpetiole broader than long, the anterior border and sides feebly convex, almost straight. There is a deep constriction between the postpetiole and first segment of the gaster, the latter broader than long.

Habitat.—Victoria: Ferntree Gully (F. P. Spry; L. B. Thorn).

It is with some doubts that this species is placed in the present genus. The epinotum and node are similar to those of the genus *Acanthoponera*, whilst the remainder are quite those of the present genus.

Genus *Eubothroponera* gen. nov.

Worker.—Monomorphic. Mandibles triangular, edentate, Maxillary palpi with four, labial palpi two segments. Eyes large and convex. No ocelli. Frontal carinae represented as small flat, horizontal plates, or lobes, overhanging the antennal insertions, not, or hardly, defined behind, widely separated. In profile the head forms an even convexity from the anterior border of the clypeus to the occipital border. Clypeus broad and convex, level with the top of the carinae. Antennae with twelve segments, scapes pass the occipital border. Suture between the pronotum and mesonotum strongly impressed. Mesoepinotum without traces of a suture. Node massive, broader than long, with a long tooth in front below. First and second segments of the gaster separated by a strong constriction. Legs long and slender, the anterior pair each with one spur, the middle and posterior pair each with two spurs, claws small and simple.

Male and female unknown.

Genotype *Eubothroponera dentinodis*, n. sp.

Near *Bothroponera*. Distinguished by its small size, large eyes and differently shaped epinotum.

KEY TO THE SPECIES.

1. Red. Node with a strong tooth at the middle of the posterior border above. *dentinodis*, n. sp.
2. Red. Head and gaster brown. Node with a slight indication of a tooth at the middle of the posterior border above *bicolor*, n. sp.
3. Brown. Epinotal declivity sharply margined. Node without a tooth above. *micans*, n. sp.

EUBOTHROPONERA DENTINODIS, n. sp.

(Text-fig. 1, Nos. 6, 6a.)

Worker.—Length, 4—4.5 mm.

Castaneous. Mandibles, antennae and legs lighter, eyes and posterior margin of the node black.

Subopaque. Head finely reticulate, with some large, very shallow, punctures. Mandibles densely punctate. Scares and thorax densely and very finely punctate, the punctures larger on the end of the epinotum. Node more coarsely punctate, almost rugose. Gaster microscopically punctate, with some large, isolated, shallow punctures.

Hair yellow, erect, long and abundant on the head, thorax, node and gaster, none on the antennae and legs. Pubescence yellow, very fine and moderately abundant, particularly on the apical segments of the gaster, very abundant and adpressed on the antennae and legs.

Head slightly longer than broad, the occipital border feebly, the sides strongly convex. Frontal carinae overhanging the antennal insertions in front, hardly defined behind. Clypeus large, convex above, level with the top of the carinae. Eyes large and convex, placed at the middle of the sides. Scares extending beyond the occipital border by twice their thickness; first segment of the funiculus as long as the second, the others subequal. Mandibles triangular, abruptly bent at their base, edentate. Thorax one and three-quarter times longer than broad. Pronotum fully one-third broader than long, convex in front and on the sides, the suture strongly impressed. Mesonotum and epinotum united without traces of a suture, the posterior border straight, feebly margined; in profile convex longitudinally, the declivity face straight, at an obtuse angle, the sides feebly margined. Node one-fourth broader than long, convex in front and on the sides, the posterior border sharply margined; there is a strong, tooth-like projection at the middle, directed backward; in profile higher than long, the anterior face vertical, as long as the dorsum, the posterior face con-

cave; there is a long, broad, blunt tooth below in front, and a smaller one behind directed backward. First segment of the gaster one-third broader than long. There is a decided constriction between the first and second segments, the latter broader than long. Legs long and slender.

Habitat.—Western Australia: Bungulla (J. Clark).

EUBOTHROPONERA MICANS, n. sp.

(Text-fig. 1, Nos. 7, 7a.)

Worker.—Length, 4—4.7 mm.

Blackish brown. Mandibles, antennae and legs brown.

Subopaque. Head, thorax and node very finely and densely reticulate, with a few isolated shallow punctures. Mandibles coarsely punctate. Scapes, legs, and gaster densely and very finely punctate; face of the declivity reticulate.

Hair yellow, erect, short and pointed, sparse throughout, very short and suberect on the legs. Pubescence long and fine, adpressed, forming a thin, but distinct, clothing on all the body.

Head one-fourth longer than broad, the occipital border feebly, the sides strongly convex. Frontal carinae overhanging the antennal insertions. Clypeus convex above, strongly convex and projecting in front. Eyes large, placed at the middle of the sides. Scapes extending beyond the occipital border by one-fourth of their length; first segment of the funiculus as long as the second, the others subequal. Mandibles triangular, abruptly bent near the base, edentate. Thorax almost twice as long as broad. Pronotum one-third broader than long, the anterior border strongly, the sides feebly, convex, the suture strongly impressed. Mesonotum and epinotum united without traces of a suture, the posterior border and sides of the declivity sharply margined; in profile convex longitudinally, the declivity abrupt, concave laterally. Node one-third broader than long, broader behind than in front, the anterior border feebly, the sides strongly convex, the posterior border straight, the dorsum flattened behind in the middle; in profile one-third higher than long, the anterior face and dorsum feebly convex, the posterior face straight; there is a long, broad, translucent tooth in front below, and a feeble one behind, directed backward. There is a well-defined constriction between the first and second segments of the gaster. Legs long and slender.

Habitat.—Western Australia: Mundaring (J. Clark).

Two small colonies of this species have been found. One, the first, was nesting in a burrow made by a trap-door spider. The second was under a piece of old bark on the ground. Both colonies appeared to be temporary, or moving; no females, eggs, larvae nor pupae were present.

Readily separated from *E. dentinodis* by the form of the head and node, as well as by the colour, sculpture and pilosity.

EUBOTHROPONERA BICOLOR, n. sp.

(Text-fig. 1, Nos. 8, 8a.)

Worker.—Length, 4·8—5·3 mm.

Red. Head and gaster brown, mandibles, clypeus, antennae and legs reddish brown.

Shining. Head, thorax and node finely and densely punctate, the punctures on the thorax a little larger than those on the head, some large shallow punctures scattered sparingly throughout. Gaster densely, microscopically punctate.

Hair yellow, short and suberect, very sparse throughout. Pubescence fine, short and adpressed, particularly on the antennae and legs.

Head slightly longer than broad, the occipital border and sides convex. Frontal carinae overhanging the antennal insertions. Clypeus strongly convex above, the anterior border strongly produced. Eyes convex, placed at the middle of the sides. Scapes extending beyond the occipital border by one-fourth of their length; first segment of the funiculus slightly longer than the second, the others subequal. Mandibles triangular, abruptly bent at their base, edentate. Thorax one and three-fourth times longer than broad. Pronotum fully one and two-third times broader than long, convex in front and on the sides. Mesonotum and epinotum united without traces of a suture, convex laterally, the posterior border not margined; in profile convex longitudinally, the declivity at an obtuse angle, the boundary between the two faces hardly defined. Node one-fourth broader than long, broader behind than in front, the anterior border straight, sides convex, the posterior border straight and submargined, with traces of a tooth in the middle. Gaster distinctly constricted between the first and second segments. Legs long and slender.

Habitat.—Western Australia: Ludlow (J. Clark).

Several specimens taken on tree trunks. No nest has been found. This species comes near *E. micans*, but can be distinguished by the form of the head and node, also by the colour, sculpture and pilosity.

BOTHROPONERA TASMANIENSIS Forel.

Pachycondyla (Bothroponera) tasmaniensis Forel, Bull. Soc.

Vaud. Sc. Nat., xlix, p. 176, 1913. ♂

I have not seen this species, but from the description given by Forel I am of the opinion that it is congeneric with the three preceding.

Subfamily FORMICINAE.

POLYRHACHIS (CHARTOMYRMA) OPALESCENS, n. sp.

(Text-fig. 1, Nos. 9, 9a.)

Worker.—Length, 5—6 mm.

Black, but so densely clothed with reddish green opalescent matter as to give it an iridescent brownish sheen.

Shining. Head and mandibles finely longitudinally striate. Thorax more coarsely so. Declivity of the epinotum transversely striate. Node smooth. Gaster very finely and densely reticulate.

Hair yellowish, very long and erect, abundant throughout, shorter and suberect on the antennae and legs. Pubescence very fine and adpressed.

Head longer than broad, convex behind and on the sides. Frontal carinae swerving outward at the middle. Clypeus carinate, broadly produced in front, feebly dentate, the angles sharp. Eyes large and convex, placed at the posterior third of the sides. Scapes extending beyond the occipital border by one-half their length; first segment of the funiculus one-fourth longer than the second, the others sub-equal to the apical. Mandibles broad, armed with five large sharp teeth. Thorax one and one-fifth times longer than broad. Pronotum one and two-third times broader than long, much broader in front than behind, the sides strongly convex, the anterior angles bluntly produced, the anterior border and sides marginate. Mesonotum twice as broad in front as long, the sides convex, marginate. The suture between the mesonotum and epinotum feebly defined, the latter twice as broad as long, furnished with two long slender spines directed backward and outward, as long as their distance apart at the base, on the side of the epinotum, between the spines and base, is a broad angular projection. In profile the dorsum and declivity united without traces of a boundary, the spines feebly inclined upward near the base, then horizontal. Node thin, furnished with two long slender spines encircling the gaster; between these, on the dorsum, is a short, blunt tooth directed upward; in profile the node is much thicker below than above, the spines almost straight. Gaster slightly longer than broad. Legs robust.

Habitat.—New Hebrides: Banaka (W. W. Froggatt).

POLYRHACHIS (HEDOMYRMA) KERSHAWI, n. sp.

(Text-fig. 1, Nos. 10, 10a.)

Worker.—Length, 6.5—7 mm.

Thorax and node bright castaneous. Apical half of the spines and the middle of the dorsum of the pronotum blackish brown. Head, mandibles, antennae, tibia, tarsi and gaster black. Femora brown.

Subopaque. Head finely and densely reticulate-punctate. Pronotum finely striate longitudinally, the anterior portion and the whole of the mesonotum finely punctate. Epinotum and node smooth and shining. Gaster microscopically punctate.

Hair brownish, erect, long and pointed, very abundant on the thorax and gaster. Pubescence yellow, long and adpressed on the

thorax and gaster, where it forms a distinct covering, but not hiding the sculpture.

Head very slightly longer than broad, broader behind than in front, the occipital border broadly convex, the sides feebly convex, the angles bluntly rounded. Frontal carinae erect, swerving behind. Clypeus carinate, bluntly produced in front. Scares extending beyond the occipital border by more than half their length; first segment of the funiculus one-fourth longer than the second, the others subequal. Mandibles armed with four to five strong sharp teeth. Thorax one and one-half times longer than broad. Pronotum much broader than long, the dorsum square, marginate on the sides, furnished on each side in front with a long sharp spine directed outward and slightly forward; in profile the spines are curved downward at the points, the dorsum convex. Mesonotum one-third broader than long, much broader in front than behind, sharply marginate on the sides, convex laterally in front, flat behind. Epinotum broader than long, sharply marginate on the sides, furnished with two long sharp spines directed backward and slightly outward, the dorsum concave; in profile the spines horizontal, abruptly bent at their base, slightly higher than the dorsum, the declivity straight, at an obtuse angle, fully twice as long as the dorsum. Node one-fourth broader than long, the anterior border straight, the posterior convex, furnished with two long, slender spines directed outward, backward and slightly upward, much wider than the epinotum, almost encircling the gaster; in profile parallel, twice as high as long, the dorsum inclined behind, the spines raised toward the points. Gaster longer than broad. Legs long and slender.

Habitat.—North Queensland: Claudie River (J. A. Kershaw).

Near *P. daemeli* Forel, but readily distinguished by the longer spines on the pronotum, colour and pilosity.

POLYRHACHIS (MYRMHOPLA) GLABRINOTUM, n. sp.

(Text-fig. 1, Nos. 11, 11a.)

Worker.—Length, 10—10.5 mm.

Black. Legs brown. Mandibles and epinotum with a brownish tinge.

Subnitid. Mandibles and pronotum shining, almost smooth. Head coarsely rugose behind the eyes, finely and densely punctate in front of the eyes. Epinotum smooth above, finely and densely punctate. Sides of the mesonotum and epinotum coarsely and irregularly rugose. Gaster, legs and antennae microscopically punctate.

Hair greyish, erect, long and pointed, abundant throughout, shorter and suberect on the antennae and legs. Pubescence greyish, very fine and adpressed, abundant throughout, slightly longer on the gaster, but not hiding the sculpture.

Head one-third longer than broad, the sides convex, the occipital produced as a bluntly rounded point. Frontal carinae erect, diverging behind. Clypeus convex, with a distinct median carina, produced in front. Eyes large and globular, placed almost at the posterior third. Scapes extending beyond the occipital border by almost one-half their length; first segment of the funiculus one-fourth longer than the second. Mandibles armed with five to six strong sharp teeth. Thorax fully twice as long as broad. Pronotum as long as broad, convex laterally, furnished with a long, slender, sharp spine at each side in front, directed outward and curved forward; in profile the dorsum strongly convex longitudinally, the spines directed downward and forward. Mesonotum longer than broad, convex above. Epinotum as long as broad, furnished with two long, slender spines, meeting at their base, directed outward, and backward, fully twice as long as those on the pronotum; in profile suberect, curved backward, the dorsum of the epinotum and mesonotum forming a straight line, much lower than the pronotum. The declivity at an obtuse angle, as long as the dorsum. Node longer than broad, the sides strongly convex, furnished with two long, sharp, slender spines, directed outward and backward, slightly longer than their distance apart at the base; in profile one-fourth higher than long, higher behind than in front, the anterior and posterior faces straight, parallel, the dorsum convex, the spines directed slightly upward. Gaster longer than broad. Legs long and slender.

Habitat.—North Queensland: Cape York (W. B. Barnard).

This species is near *P. barnardi* Clark, but is readily distinguished by its smaller size and more slender form, more shining appearance, and highly polished pronotum. The sculpture is much coarser than in *P. barnardi*. The shape of the head and node at once separate this species from *P. clotho* Forel.

POLYRHACHIS (MYRMHOPLA) BARNARDI Clark.

Journ. Roy. Soc. W. Aust., xv, p. 39, pl. i, figs. 37-38, 1928.

Female.—Length, 14.5—15 mm. Not previously described.

Resembles the worker, but is much larger and more robust. The colour, sculpture and pilosity are identical. The spines of the pronotum, epinotum and node are shorter and thicker. On the mesonotum there is a sharp longitudinal carina in the middle of the anterior half, effaced behind. A strong carina on each side takes the place of parapsidal furrows. The posterior border finely, but sharply, margined, with a sharp tooth-like corner at the junction with the lateral carina. Wings hyaline, with a smoky tinge.

Habitat.—North Queensland: Cape York (W. B. Barnard).

Since the worker was described I have received further examples of this species from Mr. Barnard, including the female.

also examples of *P. clotho* Forel. The latter is very distinct from *P. barnardi*, having a differently shaped head and node. The formation of the thorax is somewhat similar. In *P. clotho* the head is almost as broad as long, and broadly rounded behind. The spines of the epinotum are more widely separated and raised at a very slight angle. The node is higher in front than behind, more like that of *P. trapezoidea* Mayr. The pilosity is similar to that of *P. glabrinotum*, described above.

POLYRHACHIS (CAMPOMYRMA) GRAVIS, n. sp.

(Text-fig. 1, Nos. 12, 12a.)

Worker.—Length, 7.5—9 mm.

Black. Mandibles, apical segments of the antennae, legs and four posterior coxae reddish brown, anterior coxae black. In a few examples the tibiae are darker than the femora.

Shining. Head very finely striate-rugose longitudinally. Clypeus slightly rugose behind, punctate in front. Mandibles very finely and densely striate longitudinally. Pronotum longitudinally arched striate-rugose, diverging outward behind, almost transverse in front. Mesonotum and epinotum longitudinally striate-rugose, the striae following the contour of the segments. Sides of the thorax longitudinally striate, much stronger than on the dorsum, declivity transversely striate. Node transversely striate in front and behind. Gaster finely and microscopically striate-punctate, with a longitudinally arched direction. Anterior coxae finely transversely rugose.

Hair yellow, erect, very short and sparse throughout, except on the apex of the gaster.

Head slightly longer than broad, the occipital border appearing strongly convex, but really composed of three straight portions, the base, or centre, short, the portions from the base to the angles three times longer than the base, sides convex. Frontal carinae parallel, or very feebly diverging behind. Clypeus broad and convex, not carinate, the anterior border broadly produced, straight, feebly crenulate. Eyes large and convex, placed at the posterior angles. Scapes extending beyond the occipital border by more than half their length; first segment of the funiculus slightly longer than the second, the others subequal to the apical. Mandibles armed with six large, sharp teeth. Thorax one and one-half times longer than broad. Pronotum almost twice as broad as long, convex and marginate in front and sides, the posterior border almost straight, the anterior angles bluntly produced. Mesonotum broader than long, one and a-half times broader in front than behind, the sides marginate. Epinotum one-third longer than broad, fully twice as broad in front as behind, the sides strongly marginate, produced behind as short, sharp teeth, directed upward, their length equal to their distance apart at the

base. The declivity abrupt, concave, as long as the dorsum. Node thick, broader than long, furnished with four sharp, slender spines, the middle pair slightly longer than the lateral pair, longer than their distance apart, parallel, the points of the lateral pair level with the base of those in the middle. First segment of the gaster strongly margined in front, and anterior two-thirds of the sides. Legs long and slender.

Habitat.—Central Australia: Burt Plains (C. Barrett).

POLYRHACHIS (CAMPOMYRMA) FLAVIBASIS, n. sp.

(Text-fig. 1, Nos. 13, 13a.)

Worker.—Length, 7—7.5 mm.

Head, thorax and node black. Anterior border of the mandibles, funiculus, knees, tarsi and gaster brown. Femora, tibiae, base of the first segment and posterior margin of the other segments of the gaster yellow. Posterior coxae more or less splashed with yellow.

Shining. Head and thorax very finely, densely and irregularly, reticulate, slightly coarser on the thorax, reticulate-punctate on the sides. Declivity smooth and shining. Anterior and posterior faces of the node superficially reticulate. Gaster microscopically punctate.

Hair yellow, erect, very sparse, confined to the front of the head and apical segments of the gaster. Pubescence yellow, very sparse on the gaster and antennae, not apparent elsewhere.

Head longer than broad, convex behind and on the sides. Frontal carinae short. Clypeus convex, with a faint carina in the middle in front, the anterior border produced and almost straight. Eyes large and convex, placed at the posterior third of the sides. Scapes extending beyond the occipital border by barely half their length; first segment of the funiculus one-third longer than the second. Mandibles armed with five strong, sharp teeth. Thorax one and three-quarters times longer than broad, the sutures strongly impressed. Pronotum as long as broad, strongly convex in front and on the sides, the latter submarginate, feebly convex above. Mesonotum broader than long, broader in front than behind, submarginate on the sides. Epinotum square, as long as broad, the sides submarginate, the posterior border sharply marginate. Declivity face steep, concave near the bottom, longer than the dorsum, the sides rounded. Node almost twice as broad as long, the lateral angles sharp, the top edge high and narrow, furnished with two broad, triangular teeth. Gaster longer than broad, the anterior border feebly concave below. Legs short and robust.

Female.—Length, 9 mm.

Larger and more robust than the worker. Sculpture a little coarser, more reticulate-punctate. Parapsidal furrows well im-

pressed. Mayrian furrows not defined. Colour identical. Wings hyaline with a brownish tinge.

Habitat.—New South Wales: Brooklana and Dorriga (W. W. Froggatt).

Notes on the Ants of the Horn Expedition.

The collection, here re-examined, was dealt with by Mr. W. F. Kirby, Results of the Horn Expedition, Part I, Supplement, pp. 203-207, 1896. In each case the number and name given by Kirby are stated first, notes and corrections follow.

1. *Camponotus schencki* Mayr. Paisley Bluff. One specimen.

This species cannot now be traced in the collection.

2. *Camponotus impavidus* Forel. MacDonnell Range, several specimens.

This is not *impavidus*, but a species subsequently described by Wheeler as *Calomyrmex purpureus* Mayr var. *eremophilus* (*Trans. Roy. Soc. S. Aust.*, xxxix, p. 820, 1915). The material consists of workers, females and males. As Wheeler described only the worker I give here descriptions of the sexes:—

Female.—Length, 8.8-5 mm.

Head and thorax bright metallic green. Mandibles, antennae, legs and gaster black. Wings hyaline, with a slight brownish tinge. Sculpture and pilosity identical with that of the worker. Ocelli prominent. Thorax without mayrian furrows. Parapsidal furrows prominent. There is a short median, longitudinal groove on the front of the mesonotum. The anterior angles of the pronotum are subbordered; on the middle of the base of the pronotum there is a distinct raised tubercle.

Male.—Length, 6.5-7 mm.

Greenish-black throughout. Sculpture somewhat coarser than in the worker. Hair reddish, very long and abundant throughout.

Head as long as broad, broader behind than in front, the occipital border and sides strongly convex. Frontal carinae short, twice as wide behind as in front; there is a distinct longitudinal carina between them. Clypeus broad and convex. Eyes large and convex, placed at the middle of the sides. Ocelli prominent. Scapes extending beyond the occipital border by half their length; first segment of the funiculus longer than the second. Mandibles edentate. Mesonotum one third broader than long, strongly convex in front and on the sides, the anterior face steep and convex, not quite hiding the pronotum from above. Mayrian furrows not impressed, parapsidal and median furrows as in the female. Scutellum as broad as long, broader in front than behind. Epinotum broader than long. Node twice as broad as long, convex in front and behind; in profile higher than long, the anterior and posterior faces and dorsum convex. Gaster much longer than broad. Cerci

moderately long and thick. Outer genital processes slender; legs long and slender. Wings hyaline with a slight brownish tinge.

Many examples from MacDonnell Range.

3. *Camponotus arcuatus* Mayr. Hugh Creek; MacDonnell Range. Two specimens apparently belonging to this rare species.

This species cannot be traced in the collection.

4. *Camponotus reticulatus* Kirby. Paisley Bluff, burrow-nest under stones, many specimens; also Palm Creek and Finke Gorge.

This appears to be a valid species, but Kirby's name having been preoccupied by Roger, 1863 (*Berl. Ent. Zeitschr.*, vii, p. 139), I have substituted the name of the late Sir Baldwin Spencer, leader of the expedition, for the species. The major and minor workers are here more fully described as *Camponotus (Tanacnymrhex) spenceri*, nom. nov.

Worker Major.—Length, 8.5-9 mm.

Reddish brown. Mandibles red. Funiculus, tarsi and apical margin of the segments of the gaster testaceous.

Subopaque. Mandibles shining, very sparsely punctate. Head, thorax, node and first segment of the gaster finely and densely punctate-reticulate, the rest of the gaster microscopically punctate.

Hair reddish, long and erect, moderately abundant throughout.

Head very slightly longer than broad, much broader behind than in front, the occipital border straight, the sides convex. Frontal carinae diverging slightly behind, one fourth longer than their width at the middle; there is a strong carina between them. Clypeus convex above, strongly projecting at the middle in front, this portion of the clypeus as long as broad, strongly carinate, the anterior border concave. Eyes convex, placed at the posterior third of the sides. Scapes extending beyond the occipital border by one-fourth of their length; segments one to four of the funiculus almost equal in length, the others subequal. Mandibles large and triangular, armed with six strong sharp teeth. Thorax almost two and a half times longer than broad. Pronotum one-third broader than long, strongly convex in front, on the sides and above. Mesonotum circular, convex above. Epinotum narrow above, fully twice as long as broad. Node scale-like, convex in front, concave behind; in profile inclined forward, the anterior face strongly convex, posterior flat, bluntly pointed above. Gaster longer than broad. Legs long and slender.

Worker Minor.—Length, 6.7-3 mm.

Colour, sculpture and pilosity similar to the worker major. Head longer than broad, as broad in front as behind, the occipital border strongly, the sides feebly, convex. Scapes extending beyond the occipital border by half their length. The rest as in the major, but much more slender.

Habitat.—Paisley Bluff, Palm Creek, Finke Gorge.

5. *Camponotus novae-hollandiae* Mayr. MacDonnell Range; Palm Creek; Paisley Bluff.

Three species are included under this name. The specimens from Paisley Bluff are correctly placed. This is *Camponotus (Tanaemyrmex) novae-hollandiae* Mayr. The examples from MacDonnell Range are all referred to *Camponotus (Tanaemyrmex) discors* Forel, var. *laetus* Forel (*Rev. Suisse Zool.*, xviii, p. 70, 1910), subsequently described from the same locality. The specimens from Palm Creek are dealated females of the genus *Iridomyrmex*, not in condition to be described.

6. *Camponotus denticulatus* Kirby. MacDonnell Range; Paisley Bluff.

The specimen from Paisley Bluff is a dealated female of the genus *Iridomyrmex*, apparently identical with those placed under the preceding species, and not in condition to be named. The species from the MacDonnell Range appears to be valid, and is here redescribed as *Camponotus (Tanaemyrmex) denticulatus* Kirby.

Worker Minor.—Length, 8.5-9 mm.

Brownish red. Posterior half of the head, top of the pronotum and mesonotum, whole of the node and gaster black. Apical margin of the segments of the gaster yellowish.

Opaque. Densely and finely punctate throughout.

Hair yellowish, long and erect, very sparse throughout. Pubescence greyish, fine, very abundant throughout, but not hiding the sculpture. There is a row of bristles on the underside of the tibia.

Head longer than broad, as broad in front as behind, the occipital border strongly, the sides feebly, convex. Frontal carinae diverging behind, with a feeble but distinct carina between them. Clypeus broad and convex, feebly carinate, the anterior border broadly produced, convex and feebly crenulate. Eyes large and convex, placed at the posterior angles. Scapes extending beyond the occipital border by half their length; first and third segments of the funiculus of equal length, second slightly shorter. Mandibles large, armed with six large sharp teeth. Thorax two and a-quarter times longer than broad. Pronotum one-third broader than long, convex on the sides and above. Mesonotum slightly broader than long, convex above. Epinotum three times longer than broad on top, almost parallel, the declivity very short, hardly apparent. Node twice as broad as long, all four sides convex; in profile twice as high as long, parallel, the anterior and posterior faces straight, the dorsum convex. Gaster oval, longer than broad. Legs long and slender.

Worker Major.—Length, 10-10.5 mm.

Colour and sculpture as in the worker minor, but a little more shining. Pubescence not so abundant.

Head one-fourth broader than long, much broader behind than in front, the occipital border straight, the sides convex. Scapes extending beyond the occipital border by fully one-third of their

length. Eyes large and rather flat, placed about half their diameter from the occipital border. Ocelli represented by three small depressions, the anterior largest. Thorax similar but larger. Node three times broader than long, straight in front and behind, sides convex; in profile scale-like, the anterior face strongly convex, the posterior straight. Legs robust.

Habitat.—MacDonnell Range.

7. *Camponotus horni* Kirby. Palm Creek, burrow nest under stone.

Kirby says: "The peculiar structure of this species will probably ultimately necessitate its removal to another genus, but the rufous body and purple abdomen will render it easily recognisable." In this statement he is correct, for the worker is *Iridomyrmex detectus* Smith, the most common and widely distributed ant. in Australia. The female appears to be a valid species, and is here redescribed as *Camponotus (Tanaemyrmex) horni* Kirby.

Female.—Length, 13 mm.

Black. Inner edge of the mandibles, front of the face, antennae and pronotum ferrugineous. Legs testaceous. Tarsi and knees darker. Wings hyaline with a brownish tinge.

Shining. Head, pronotum and epinotum finely and densely reticulate-punctate. Mesonotum, scutellum and gaster superficially so.

Hair reddish, long and erect, rather sparse throughout. Pubescence reddish, short and sparse.

Head longer than broad, broader behind than in front, the occipital border feebly convex, the sides nearly straight. Frontal carinae diverging widely behind, with a longitudinal median groove between them. Clypeus feebly carinate, the anterior border produced, straight, or feebly concave. Eyes large, rather flat, their distance from the occipital border somewhat less than their diameter. Ocelli large. Scapes passing the occipital border by one-fourth of their length. Thorax almost twice as long as broad. Pronotum small, hardly visible from above. Mesonotum broader than long, strongly convex in front and on the sides, flattened, or feebly convex, above. Parapsidal furrows impressed. Scutellum broader than long, broader in front than behind. Epinotum twice as broad as long, the declivity steep, but without a defined boundary on the dorsum. Node scale-like, fully three times broader than long, convex in front, straight behind; in profile strongly convex in front, the top edge sharp. Gaster longer than broad. Legs long and slender.

Habitat.—Palm Creek.

8. *Hoplomyrmex micans* Mayr. Storm Creek, four specimens.

This has no connection with Mayr's species, but is identical with that subsequently described by Wheeler as *Polyrhachis (Camponymma) macropus* (*Trans. Roy. Soc. S. Aust.*, xxxix, p. 821, 1915). It is widely distributed throughout Central Australia.

9. *Hypoclinea flavipes* Kirby. Tempe Downs. Ants from Porcupine grass (*Triodia pungens*).

This very distinct species is an *Iridomyrmex*, and identical with that subsequently described by Forel as *Iridomyrmex rostrinotus* (*Rev. Suisse Zool.*, xviii, p. 53, 1910, ♂ ♀ ♂). The descriptions of all three forms by Forel are very complete, and it is unfortunate that his name must give way to *Iridomyrmex flavipes* Kirby. It is known as the Spinifex Ant, being so named from its habit of collecting the gum from the leaves of this grass to construct its nest. It is widely distributed, being found wherever the spinifex grows.

10. *Bothroponera denticulata* Kirby. Blood Creek; several specimens.

This distinct species is near *B. regularis* Forel, subsequently described from Western Australia. It is widely distributed throughout the interior. The worker is here re-described:—

Worker.—Length, 12 mm.

Black, or blackish brown. Inner half of the mandibles, antennae and legs ferrugineous.

Opaque. Head coarsely reticulate. Thorax more coarsely and irregularly reticulate, with a more or less longitudinal direction. Node, first and second segment of the gaster longitudinally striate. Posterior face of the node smooth and shining.

Hair brown, suberect, long and abundant throughout, but longer and more numerous on the apical segments of the gaster. Pubescence very fine and adpressed.

Head as long as broad, as broad in front as behind, the occipital border straight, the sides feebly convex. Frontal carinae raised and lobe-like, as broad in front as long; between them is a long double carina with a median longitudinal groove. Clypeus short, convex, the anterior border bluntly produced in the middle in front. Eyes large, placed fully their diameter from the anterior border. Scapes passing the occipital border by fully their thickness; second segment of the funiculus slightly longer than the first, the apical as long as the two preceding together. Mandibles broad, armed with eight to ten irregular teeth, the apical five long and sharp, the others decreasing in size to the base. Thorax barely twice as long as broad. Pronotum almost twice as broad as long, strongly convex in front and on the sides. Pro-mesonotal suture sharply defined. In profile the thorax is evenly convex longitudinally, the declivity at an obtuse angle, rather flat, the boundary between the two faces feebly defined. Node almost twice as broad as long, the anterior face and sides strongly convex, posterior face straight, furnished with numerous long sharp teeth; these are a continuation of the dorsal striae; in profile fully twice as high as long, subparallel, the anterior face and dorsum united in a convexity, posterior face straight to near the top, then abruptly curved backward; there is a long, broad concave projection on the ventral surface. Postpetiole one third broader than

long, strongly convex in front and on the sides, slightly narrower than the following segment, which is broader than long. Legs robust.

Habitat.—Blood Creek.

11. *Myrmecia nigriceps* Mayr. Reedy Hole; Bagot Creek and Alice Springs, one specimen from each; Ayers Rock and Illamurta, several specimens from each.

This has been so determined by various entomologists until it was recognised by Wheeler, who described the worker as *Myrmecia vindex* Smith var. *desertorum* (*Trans. Roy. Soc. S. Aust.*, xxxix, p. 805, 1915). On examining large series, including the sexes, from various parts of Central and Western Australia, I raised it to the rank of species, *Myrmecia desertorum* Wheeler (Clark, *Vic. Naturalist*, xlii, p. 143, 1925, ♂ ♀ ♂).

12. *Pheidole longiceps*, Mayr. Paisley Bluff, in burrow nest under stone.

Wrongly identified by Kirby and subsequently described by Forel as *Pheidole deserticola* (*Rev. Suisse Zool.*, xviii, p. 34, 1910, 4 ♂ ♂).

The following species were described by Froggatt, Horn Exped. Zool., Part 2, 1896. As there are some doubts concerning the two species, I append a few notes, having examined the types in the National Museum.

- (1) *Camponotus cowlei* Frogg., l.c., p. 387, pl. xxvii, figs. 1-5.

Examples compared with Lubbock's type of *Melophorus bagoti*, by my friend, Mr. W. C. Crawley, are identical with the types in the National Museum. This species is widely distributed throughout Central and Western Australia, and is known as the yellow honey-ant. The synonymy of this species is as follows:—

MELOPHORUS BAGOTI Lubbock.

Journ. Linn. Soc. Lond. Zool., xvii, p. 51, 1883.

Camponotus cowlei Frogg.

Melophorus cowlei Wheeler, Bull. Amer. Mus. Nat. Hist., xxiv, p. 388, 1908.

Camponotus (*Myrmophyma*) *cowlei* Emery, Gen. Insect., Fasc. 183, p. 110, 1925.

- (2) *Camponotus midas* Froggatt, l.c., p. 390, pl. xxvii, figs. 6-9.

This species was wrongly placed in the subgenus *Myrmophyma* by Emery (*Gen. Insect.*, Fasc. 183, p. 111, 1925). It is placed in the sub-genus *Myrmosaulus*, near *C. (M.) aurocineta* Smith. The workers and female are redescribed below.

CAMPONOTUS (MYRMOSAULUS) MIDAS Froggatt.

Worker Major.—Length, 14-15 mm.

Dark brown, almost black. Head, epinotum, node and femora.

brown, or reddish brown. Posterior half of the first segment of the gaster, and the whole of the others bright golden yellow.

Opaque. Densely and finely reticulate-punctate throughout. Mandibles coarsely striate.

Hair reddish, long and erect, sparse throughout. Pubescence very fine and adpressed. Tibia with two rows of slender bristles. Tarsi with stronger and more numerous bristles.

Head large, one-third broader than long, almost twice as broad behind as in front, the occipital border concave, the sides strongly convex. Frontal carinae short, diverging behind, with a faint longitudinal groove between them. Clypeus convex, finely crenulate. Eyes small and flat, placed at the posterior third of the sides, the anterior ocellus small, situated in a pit, or cavity, the posterior ocelli hardly apparent. Scapes extending beyond the occipital border by barely their thickness; first segment of the funiculus as long as the third, second slightly shorter. Mandibles broad, armed with six large teeth, including the apex. Thorax one and a half times longer than broad. Pronotum four times broader than long, strongly convex in front and on the sides. Mesonotum large, three times longer than the pronotum, circular, or very slightly longer than broad. Epinotum short and broad, without traces of a boundary between the dorsum and declivity; in profile strongly convex longitudinally, highest at the middle of the dorsum, much lower than the mesonotum. Node fully one third broader than long, broader behind than in front, the anterior and posterior faces straight, sides convex; in profile one third higher than long, parallel, the dorsum convex. Gaster ovate, longer than broad. Legs robust.

Worker media.—Length, 11-12 mm.

Colour, sculpture and pilosity as in the major.

Head slightly longer than broad, slightly broader behind than in front, the occipital border and sides strongly convex. Clypeus more distinctly carinate. Eyes a little more convex. Mandibles armed with eight teeth, including the apex. Scapes extending beyond the occipital border by fully half their length. The epinotum is abruptly truncate in front, forming a deep and wide constriction; in profile strongly convex from the top of the truncature to the bottom of the declivity, the cavity between the mesonotum and epinotum almost as long as the dorsum of the latter. Node as long as broad, much broader behind than in front, the anterior border slightly concave, the posterior and sides convex; in profile as long as high, the anterior face straight, the dorsum and posterior face feebly convex. Gaster longer than broad. Legs long and robust.

Worker Minor.—Length, 9-10 mm.

Colour darker, except on the gaster. Sculpture and pilosity similar.

Head longer than broad, the occipital border strongly convex, the sides parallel, feebly convex. Clypeus feebly carinate. Eyes

large, at the posterior third of the sides. Thorax similar. Node one fourth longer than broad, broader behind than in front, the anterior border feebly concave, the posterior border and sides convex. Legs long and slender.

Female.—Length, 16.4 mm.

Colour, sculpture and pilosity similar to the major.

Head narrower. Clypeus feebly carinate. Mesonotum, with distinct parapsidal furrows, and a faint longitudinal groove in the middle, flattened above. Scutellum convex, high. Node as in the major. Wings hyaline, with a brownish tinge, particularly at the apex.

Habitat.—Illamurta, in the James Range.

This species is very near *C. aurocincta* Smith, from which it may be distinguished by the shape of the thorax and node, and the colour of the gaster. In *C. aurocincta* the posterior margin of the segments is narrowly yellow. In *midas* the whole of the segments, except the base of the first, are entirely bright golden yellow.

FIG. 1.

- | | |
|---|------------------------------|
| 1. <i>Eusphinctus</i> (<i>Nothosphinctus</i>) <i>brunnicornis</i> , n. sp. | Dorsal view of worker. |
| 2. <i>Phyracaces</i> <i>clarus</i> , n. sp. | Dorsal view of worker. |
| 3. <i>Phyracaces</i> <i>flammeus</i> , n. sp. | Dorsal view of worker. |
| 4. <i>Phyracaces</i> <i>flavescens</i> , n. sp. | Dorsal view of worker. |
| 5. <i>Euponera</i> (<i>Trachymesopus</i>) <i>pachynoda</i> , n. sp. | Dorsal view of worker. |
| | a, Lateral view of worker. |
| 6. <i>Eubothroponera</i> <i>dentinodis</i> , n. sp. | Dorsal view of worker. |
| | a, Lateral view of worker. |
| 7. <i>Eubothroponera</i> <i>micans</i> , n. sp. | Dorsal view of worker. |
| | a, Lateral view of worker. |
| 8. <i>Eubothroponera</i> <i>bicolor</i> , n. sp. | Dorsal view of worker. |
| | a, Lateral view of worker. |
| 9. <i>Polyrhachis</i> (<i>Chariomyrma</i>) <i>opalescens</i> , n. sp. | Dorsal view of worker. |
| | a, Lateral view of worker. |
| 10. <i>Polyrhachis</i> (<i>Hedomyrma</i>) <i>kershawii</i> , n. sp. | Dorsal view of worker. |
| | a, Lateral view of worker. |
| 11. <i>Polyrhachis</i> (<i>Myrmhopla</i>) <i>glabrino-</i>
<i>tum</i> , n. sp. | Dorsal view of worker. |
| | a, Lateral view of worker. |
| 12. <i>Polyrhachis</i> (<i>Campomyrma</i>) <i>gravis</i> , n. sp. | Dorsal view of worker. |
| | a, Lateral view of worker. |
| 13. <i>Polyrhachis</i> (<i>Campomyrma</i>) <i>flavibasis</i> , n. sp. | Dorsal view of worker. |
| | a, Lateral view of worker. |
| 14. <i>Camponotus</i> (<i>Myrmosaulus</i>) <i>midas</i> Froggatt | Dorsal view of worker major. |
| | a, Lateral view of same. |
| 15. <i>Camponotus</i> (<i>Myrmosaulus</i>) <i>midas</i> Froggatt | Dorsal view of worker minor. |
| | a, Lateral view of same. |

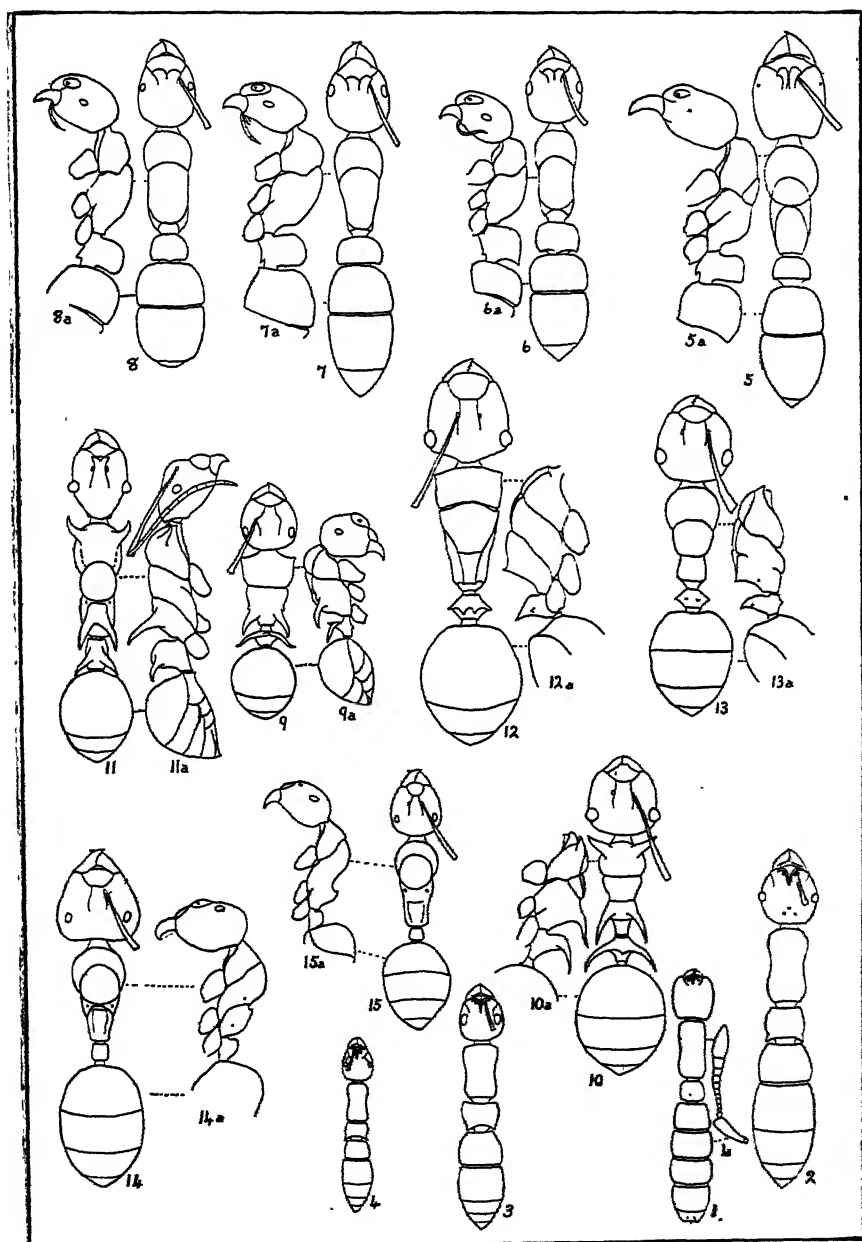


FIG. 1.

ART III.—*New Hymenoptera Proctotrypoidea from Victoria.*

By ALAN P. DODD.

(Communicated by F. E. Wilson, F.E.S.)

[Read 12th June, 1930; issued separately 8th September, 1930.]

The material from which this paper was prepared was submitted by Mr. F. Erasmus Wilson. Six new species are proposed, three of which are placed in *Xenotoma* Foerster, a Belytid genus not previously recognised in Australia. In addition, the males of *Prosoxylabis pictipennis* Dodd (Belytidae), *Neobetyla spinosa* Dodd (Belytidae), and *Hemilexomyia abrupta* Dodd (Diapriidae) are made known.

Family SCELIONIDAE.

OPISTHACANTHA NUBILA, n. sp.

Female.—Length, 1.75 mm. Jet black, the antennae concolorous, the articulate joint of the scape yellow; coxae and femora black, the trochanters yellow, the tibiae and tarsi dusky yellow-brown.

Head normal, the vertex moderately long, and sloping gently posteriorly to the concave occipital margin; frons gently convex, from frontal aspect somewhat wider than deep, not depressed above the antennal insertion; cheeks moderately broad; eyes moderately large, bearing scattered hairs; ocelli small, wide apart, the lateral pair situated close to the eyes; head wholly smooth and polished, the cheeks and frons with scattered fine hairs, the vertex with scattered long black hairs. Antennal scape long and slender; pedicel almost twice as long as its greatest width; funicle 1 as long as the pedicel, 2 shorter than 1, one-third longer than wide, 3 quadrate, 4 small, much wider than long; club compact, joints 1-5 each twice as wide as long. Thorax about one-fourth longer than its greatest width; pronotum visible from above as a narrow line laterally, armed with a row of stout black hairs; anterior margin of scutum very broadly rounded, the median lobe anteriorly with a declivous area, devoid of pubescence, separated by a transverse groove a little in front of the anterior end of the parapsidal furrows; parapsidal furrows delicate, complete, rather wide apart; scutum and scutellum smooth, with a scattered pubescence of fine hairs and of long stout black hairs; scutellum semi-circular, with a row of punctures along its anterior and posterior margins; metanotum short, foveate, armed medially with an acute horizontal tooth; propodeum broadly and deeply divided to its base to receive the base of the abdomen, so that lateral triangular areas only are visible, the posterior angles sub-acute. Forewings rather short, extending to apex of fourth abdominal segment; rather narrow,

$3\frac{1}{2}$ times as long as the greatest width; marginal cilia moderately long, the discal cilia fine and dense; distinctly stained brownish; venation fuscous, armed with stout long hairs or bristles except on the stigmal vein; marginal vein two-thirds as long as the stigmal, which is moderately long and very oblique, the postmarginal over twice as long as the stigmal vein; basal vein marked by a thick light brown line, the median vein by a fainter line. Legs normal, the femora, tibiae, and tarsi slender; posterior tarsi no longer than their tibiae, their basal joint a little shorter than 2—5 united. Abdomen one-third longer than the head and thorax united; $2\frac{1}{2}$ times as long as its greatest width; slightly wider than the thorax; narrowed at base but not sub-petiolate, almost pointed at apex, the lateral margin regularly convex from base to apex; segment 1 as long as its basal width, which is two-thirds the posterior width, with a slight hump at base medially; 2 almost twice as long as 1; 3 one-half longer than 2, almost as long as 4—6 united; 4 somewhat longer than 5; 5 and 6 subequal; 1 strongly striate, smooth at base medially; 2 strongly striate but rather broadly smooth laterally and posteriorly; the rest smooth; 4—6 and lateral and posterior margins of 2 and 3 with fine pubescence.

Male.—Unknown.

Habitat.—Victoria: Bogong Plains, 5,000—6,000 feet, two females taken in tussocks in January, F. E. Wilson.

Holotype in the collection of F. E. Wilson. Paratype in the Queensland Museum.

A very dark species, recognised by the smooth head, scutum and scutellum with their long black hairs. In the paratype the abdomen is deformed, in that segment 2 appears as a narrow sclerite on one side only, segment 3 thus joining 1 broadly.

BARYCONUS CURTATUS, n. sp.

Female.—Length, 1.90 mm. Head chestnut-red, the vertex dusky, the eyes and ocelli black; thorax bright chestnut-red; abdomen brownish-black, the third segment orange-red; antennae black, the scape reddish-yellow, dusky toward apex; coxae clear yellow-brown, the legs suffused with dusky, the tibiae blackish.

Head normal; vertex moderately long, sloping gently from the line of the lateral ocelli to the posterior margin, which is gently concave; frons somewhat wider than deep, from lateral aspect lightly convex, not depressed above the antennal insertion, with a delicate median carina for one-half its length from the antennal insertion; cheeks broad; mandibles tridentate, the teeth acute, almost subequal; eyes moderately large, faintly pubescent; ocelli small, wide apart, the lateral pair against the eyes; head smooth, polished, with scattered small punctures bearing fine hairs; vertex with fine impressed polygonal reticulation but smooth medially behind the anterior ocellus, and narrowly against the occipital margin; mouth with short converging striae. Antennal scape long

and slender, its articulate joint long; pedicel slender, $2\frac{1}{2}$ times as long as its greatest width; funicle 1 a little shorter than the pedicel, twice as long as its greatest width, 2 somewhat longer than wide, 3 quadrate, 4 small and transverse; club compact, 6-jointed, 1—5 each twice as wide as long, 1 small, 3 slightly the widest. Thorax from dorsal aspect not much longer than its greatest width; pronotum very narrowly visible; anterior margin of scutum rather sharply convex; median lobe of scutum divided anteriorly by a transverse groove at the anterior end of the parapsidal furrows; parapsidal furrows complete, rather delicate; scutum smooth, with small scattered punctures bearing pale hairs and with a narrow line of scaly reticulation on either side at the parapsidal furrows; scutellum semi-circular, smooth, with scattered small punctures bearing fine hairs, its posterior margin finely foveate; metanotum short, transverse, smooth, declivous, not prominent; propodeum finely sculptured, very short, the posterior margin faintly concave and rather broadly divided medially, the posterior angles acute. Forewings short, reaching to posterior margin of segment 3 of abdomen; slender, four times as long as their greatest width; distinctly dusky; venation fuscous; marginal vein one-half as long as the stigmal, which is oblique and rather short, the postmarginal a little less than twice as long as the stigmal; basal and median veins marked by brown lines; hindwings almost as long as the forewings. Legs normal, slender; posterior tarsi no longer than their tibiae, their basal joint as long as 2—5 united. Abdomen one-half longer than the head and thorax united, $2\frac{1}{2}$ times as long as its greatest width, which is somewhat greater than that of the thorax; narrowed at base, almost pointed at apex, the apical segment not stylate; segment 1 a little shorter than its basal width, a little wider posteriorly than basally, somewhat raised at base but without a distinct prominence, its anterior margin straight; 2 one-half longer than 1; 3 one-half longer than 2, as long as 4—6 united, one-fourth wider than long; 4—6 gradually shortening; 1 striate, smooth medially at base; 2 strongly striate for less than its basal half; rest of abdomen smooth; 4—6 and lateral margins of 1—3 with scattered fine hairs.

Male.—Unknown.

Habitat.—Victoria: Bogong Plains, 5,000—6,000 feet, two females taken in tussocks in January, F. E. Wilson.

Holotype in the collection of F. E. Wilson. Paratype in the Queensland Museum.

Readily distinguished from other Australian species in the genus by the shorter wings.

TELENOMUS WILSONI, n. sp.

Female.—Length, 1.50 mm. Black; antennae black, the scape deep red at extreme base; coxae and femora black, the trochanters fuscous, the tibiae and tarsi bright red.

Head very wide and transverse, somewhat distinctly wider than the thorax, the vertex very thin, and descending sharply to the foveate occipital margin, which is gently concave; from frontal aspect the head is plainly wider than deep; eyes wide apart, large, bare; ocelli large, very wide apart, the lateral pair almost touching the eyes; vertex, upper frons, lateral margins of frons against the eyes, and between the ventral end of the eyes and the mouth, with fine pale pubescence, dense fine coriaceous-reticulate sculpture and obscure shallow punctures; lower two-thirds of frons, except against the eye margins, with strong transverse striae joining an ill-defined median carina; cheeks very narrow, rugose. Antennae 11-jointed; articulate joint of scape rather long and slender; scape slender, as long as the next four joints combined; pedicel twice as long as its greatest width; funicle 1 one-half longer than the pedicel, three times as long as its greatest width; 2 a little less than one-half as long as 1, a little longer than wide; 3 somewhat wider than long; club rather slender, 6-jointed, but not well differentiated from the funicle, joint 1 somewhat wider than funicle 3, wider than long, 2 the largest and sub-quadrate, 3—5 wider than long. Thorax stout, from dorsal aspect no longer than wide, from lateral aspect shorter than its height, the dorsal outline strongly convex; pronotum narrowly visible laterally; scutum somewhat convex, finely pubescent, with rather strong irregular rugose-punctate sculpture which on the posterior half medially has a definite tendency toward irregular longitudinal rugae; parapsidal furrows absent; scutellum semi-circular, strongly irregularly rugose-punctate and with fine pubescence; metanotum situated below the scutellum, a prominent transverse rugose plate which hides the short propodeum medially; propodeum short, broad, broadly hidden medially, visible as rugose lateral areas only. Forewings extending a little beyond apex of abdomen; broad, a little more than twice as long as the greatest width; distinctly fumated around the stigmal vein; marginal cilia short; discal cilia fine and dense; venation deep brown; marginal vein almost one-half as long as the stigmal, which is slender and very long, the postmarginal a little less than twice as long as the stigmal. Femora a little thickened; tibiae moderately slender; tarsi slender, the posterior tarsi a little longer than their tibiae, their basal joint as long as 2—5 united. Abdomen one-third longer than its greatest width, broad at base; segment 1 short and transverse; 2 two-thirds as long as wide; 3—6 combined two-thirds as long as 2; 1 strongly sparsely striate, its lateral margins smooth and with a few hairs; 2 at base, except laterally, with a row of foveae, densely rather finely striate for two-thirds its length, smooth for its posterior third and along lateral margins, where there are scattered hairs; 3—5 rather densely pin-punctate, each with a row of fine hairs at one-half the length.

Male.—Unknown.

Habitat.—Victoria: Eltham, thirteen females collected by F. E. Wilson, in May, associated with an ant.

Holotype in the collection of F. E. Wilson. Paratypes in the collections of the Queensland Museum, F. E. Wilson, and the author.

At once separated from the many Australian species by the lengthened first funicle joint of the antennae. I have much pleasure in naming this species after the discoverer, whose enterprise has brought to light the several new species described in this paper.

Family BELYTIDAE.

Xenotoma Foerster.

This world-wide genus, with over eighty known species, has not previously been recognised in Australia. The three forms described below, all from Victoria, may be separated by means of the following key:—

1. Larger apical spur of posterior tibiae two-thirds as long as the first tarsal joint; petiole one-half as long as body of abdomen; recurrent vein very short *X. longispina*.
 Larger apical spur of posterior tibiae one-third as long as the first tarsal joint; petiole not more than one-third as long as body of abdomen; recurrent vein as long as the radial 2.
2. Forewings hyaline; antennal scape a little longer than the next two joints united *X. claripennis*.
 Forewings cloudy with hyaline areas; scape as long as the next four joints united *X. variipennis*.

XENOTOMA VARIIPPENNIS, n. sp.

Female.—Length, 3.40 mmr. Head black; thorax blackish, the pronotum, posterior half of median lobe of the scutum, and many of the segmental sutures, deep red, the tegulae yellow; abdominal petiole blackish, the abdomen dull chestnut-brown, blackish apically, and along the lateral margins; coxae fuscous, the legs brownish-yellow, the posterior tibiae and tarsi dusky; antennae black, the scape bright testaceous, the pedicel and basal funicle joints sometimes suffused reddish.

Head from dorsal aspect transverse; from frontal aspect wider than deep; from lateral aspect the frons convex; without sculpture but with a rather dense pale pubescence; eyes very wide apart, with scattered hairs; ocelli close together; mandibles long, crossed, falcate. Antennae 15-jointed; scape slender, somewhat curved, very long, as long as the next four joints united; pedicel hardly twice as long as wide; flagellar joints filiform, 1 almost twice as long as the pedicel, 2—12 gradually shortening, 12 as long as the pedicel, the apical joint one-half longer than the preceding.

Thorax two-thirds longer than its greatest width; pronotum narrowly visible, its angles sub-acute; parapsidal furrows complete, deep, a little curved against the posterior margin; scutum and scutellum with a pubescence of rather scattered long pale hairs; scutellum somewhat declivous posteriorly, with a deep wider-than-long basal fovea; metanotum transverse, depressed laterally, the median area with a strong median carina and more delicate lateral carinae; propodeum moderately long, smooth, with scattered fine pubescence, with a strong median and lateral carinae, the posterior margin carinate and gently concave, the lateral margins carinate, the posterior-lateral angles in the form of projecting small acute teeth. Forewings long and broad; fumated, the colour being darker and blackish against the distal margin, with two large hyaline areas, one against either border in the distal half of the wing, and there is a narrow hyaline area beneath the distal portion of the submarginal vein from the junction of the basal vein; venation dark, complete; marginal vein two-thirds as long as the closed radial cell; recurrent vein as long as the radial, its apex directed to the base of the discoidal vein. Legs normal, slender, as in *claripennis*. Abdominal petiole slender, $2\frac{1}{2}$ times as long as its greatest width, less than one-third as long as the abdomen, striate; body of abdomen narrowed at base, pointed at apex, over twice as long as its greatest width, with scattered hairs, finely striate at extreme base; composed of five segments; segment 2 (first body segment) fully twice as long as 3—6 united, 3 not greatly longer than 4, 5 very short and transverse, 6 as long as 3; oviduct prominent in the form of a short stylus.

Male.—Differs from the female in that the head, thorax, and abdomen are wholly black; body of abdomen somewhat shorter, not more than twice as long as its greatest width and a little less than three times as long as the petiole, composed of seven segments (excluding the petiole), segment 2 fully four times as long as 3—8 united, 3—7 all very transverse, 8 broadly rounded at apex. Antennae black, the scape clear testaceous, the pedicel brown; 14-jointed; pedicel stout, one-third longer than its greatest width; flagellar joint 1 three times as long as the pedicel, two-thirds as long as the scape, excised on one side at half its length; 2—11 very gradually shortening, 11 two-thirds as long as 1, the apical joint slightly longer than the penultimate.

Habitat.—Victoria: Grampian Mts., Macedon, Belgrave, Healesville, three females, one male collected by F. E. Wilson, two males taken by A. P. Dodd, in October, December, March, April, and June.

Holotype in the collection of Mr. F. E. Wilson. Allotype in the Queensland Museum. Paratypes in the collections of F. E. Wilson and the author.

XENOTOMA CLARIPENNIS, n. sp.

Female.—Length, 3.10 mm. Black; prothorax, scutellum, and posterior half of median lobe of the scutum, chestnut-brown; tegulae bright yellow; antennae black, the scape reddish-yellow, the pedicel brown; legs, including the coxae, clear reddish-yellow, the posterior tarsi dusky.

Head much as in *variipennis*, the frons from lateral aspect rather more strongly convex owing to the antennal prominence being more distinct; smooth with a moderately dense pubescence of fine pale hairs; eyes with a few hairs; mandibles long, crossed, falcate. Antennae 15-jointed; scape slender, a little longer than the next two joints combined; pedicel two-thirds longer than wide; flagellar joints filiform, 1 twice as long as the pedicel, 2—12 gradually shortening, 12 as long as the pedicel, the apical joint one-half longer than the penultimate. Thorax much as in *variipennis*, the pronotal angles sub-acute; pubescence of scutum and scutellum very scattered; propodeum and its carinae as in *variipennis*, but the posterior margin is faintly carinate, and the acute posterior angles project outwardly. Forewings long and broad; sub-hyaline; venation blackish; marginal vein one-half as long as the radial cell. Legs slender, the posterior tibiae and tarsi long and slender; apical spurs of posterior tibiae not very long, the longer spur not more than one-third as long as the basal tarsal joint. Abdominal petiole slender, one-third as long as the body of the abdomen, $2\frac{1}{2}$ times as long as its basal width, strongly striate, with scattered long hairs laterally; body of abdomen over twice as long as its greatest width, with a short basal stalk which continues the outline of the petiole; smooth, with scattered long fine hairs; composed of five segments, segment 2 (first body segment) fully three times as long as 3—6 united, its base striate and with a longer median groove; relative length of 3—6 about as in *variipennis*; oviduct shortly prominent.

Male.—Unknown.

Habitat.—Victoria: Grampian Mts., three females in October, F. E. Wilson.

Holotype in the collection of F. E. Wilson. Paratypes in the collections of F. E. Wilson and the author.

This species is very similar to *variipennis*, but differs in the clear wings, the chestnut-brown scutellum, the clear yellow coxae, the shorter scape in relation to the following joints, and the narrowing of the base of the abdomen.

A female taken at Belgrave, Victoria, in January, by F. E. Wilson, differs in several particulars, and may be a distinct species; the scutellum is black; the posterior coxae are dusky; the abdominal petiole is finely densely striate; the body of the abdomen is not more than twice as long as its greatest width, and is not stalked at base; the distal margin of the forewing is definitely, although lightly, smoky.

XENOTOMA LONGISPINA, n. sp.

Female.—Length, 3.25–3.65 mm. Black, the prothorax and posterior half of median lobe of the scutum deep red, the tegulae yellow; antennae black, the first two joints clear testaceous, the third and fourth brownish-yellow; legs clear testaceous, the posterior coxae and all femora, except at base, fuscous, the posterior tibiae brownish.

Head normal, transverse, the frons rather gently convex, the antennal prominence not large; with a moderately dense pubescence of fine pallid hairs; eyes with a few hairs; mandibles long, crossed, falcate. Antennal scape moderately long, a little longer than the next two joints combined; pedicel one-half longer than wide; flagellum filiform, joint 1 $2\frac{1}{2}$ times as long as the pedicel, two-thirds as long as the scape, 2 two-thirds as long as 1, 2–12 gradually shortening, 12 a little longer than wide, the apical joint a little longer than the penultimate, but a little shorter than 2. Thorax normal, from lateral aspect strongly convex above; pronotum, scutum, and base and lateral margins of scutellum, with a conspicuous golden pubescence; pronotal angles sub-acute; parapsidal furrows deep and complete; basal fovea of scutellum deep; median carina of metanotum delicate, the lateral carinae of the raised median area absent; propodeum smooth, the median carina rather strong, the lateral carinae fine, the posterior margin almost straight, the posterior angles not prominent. Forewings long and broad; sub-hyaline; marginal vein somewhat less than one-half as long as the closed radial cell; stigmal vein curved, slightly longer than the marginal vein; recurrent vein very short. Legs spiny, not as slender as in *variipennis* and *claripennis*; femora distinctly thickened, and with a basal stalk; larger apical spur of the posterior tibiae very long, two-thirds as long as the basal tarsal joint. Petiole of abdomen long, one-half as long as the body of the abdomen, four times as long as its greatest width; body of abdomen somewhat compressed, rather slender, over $2\frac{1}{2}$ times as long as its greatest width, smooth, with a few fine scattered hairs; composed of five segments; segment 2 (first body segment) over twice as long as 3–6 united; 3 twice as long as 4, which is very transverse; 5 as long as 3; 6 somewhat longer than 5; 5 and 6 strongly compressed; base of 2 with a median groove and traces of short striae.

Male.—Length, 2.80 mm. Differs from the female in having the scutum wholly black; the pubescence of the head and thorax is rather sparser; body of abdomen somewhat shorter, $2\frac{1}{2}$ times as long as its greatest width, the apical segments shortened, segment 2 being four times as long as the following segments united, composed of seven segments of which the apical two are curved downward; legs darker, the tibiae and tarsi being dusky-brown. Antennae 14-jointed, about as long as the body; black, the scape and pedicel reddish-yellow, the first flagellar joint reddish at base;

flagellar joint 1 two-thirds as long as the scape, slightly excised on one side, 2 a little shorter than 1, 2—11 gradually shortening, 11 two-thirds as long as 1, the apical joint slightly longer than the penultimate.

Habitat.—Victoria: Eltham, one female in August. F. E. Wilson; Belgrave, one female in January, F. E. Wilson, one male in December, A. P. Dodd.

Holotype in the collection of F. E. Wilson. Allotype in the Queensland Museum. Paratype in the author's collection.

At once differing from *varipennis* and *claripennis* in the very long spine of the posterior tibiae, the stouter femora, the short recurrent vein, and the longer abdominal petiole.

NEOBETYLA SPINOSA Dodd.

Trans. Roy. Soc. South Aust., 1, p. 298, 1926.

This species was erected on a female from the Blackall Range, South Queensland. I have seen a pair collected from tussock grass, Mt. Arapiles, Victoria, October, 1927. In comparison with the holotype, the Victorian female differs somewhat in colour in that the antennae are brownish apically, the legs are deeper reddish, and the abdomen is blackish at base and bears a broad incomplete black band at one-half its length. The male of *Neobetyla* was unknown previously, and it is interesting to learn that, as in the female, the wings are vestigial and the thorax is of the narrow type associated with wingless or semi-wingless forms.

Male.—Head deep red; thorax blackish, the scutum and scutellum red; abdomen black. Thorax as in the female; wings represented by short flaps. Body of abdomen showing five segments; segments 3 and 4 very short, 5 a little longer but transverse, 6 as long as 5, transverse, truncate at apex. Antennae 14-jointed; golden-yellow, the apical joints brownish; a little longer than the body; pedicel short, a little longer than wide; flagellar joints cylindrical, 1 longest, three-fifths as long as the scape, 2—11 gradually shortening, 11 two-thirds as long as 1.

PROSOXYLABIS PICTIPENNIS Dodd.

Proc. Linn. Soc. N.S.W., xl, p. 445, 1920.

This species was described from a single female from Tasmania in the collection of Mr. W. W. Froggatt. A male from Victoria, taken at Belgrave in January by Mr. F. E. Wilson, agrees very well with the original description, and probably represents the same species. The head, thorax (except the bright chestnut scutum), petiole, and body of abdomen are darker, being almost black. The scutellar tooth is stout and acute. Antennae 14-jointed; black, the first two joints red, the third suffused with red; scape moderately long and stout; pedicel a little longer than

wide; flagellar joints filiform, 1 a little more than one-half as long as the scape, excised on one side, 2—11 gradually shortening, 11 one-half as long as 1, the apical joint twice as long as the penultimate.

Family DIAPRIIDAE.

HEMILEXOMYIA ABRUPTA Dodd.

Proc. Linn. Soc. N.S.W., xl, p. 443, 1920.

This species was described from several females reared from pupae of sheep-maggot flies, *Ophyra*, *Calliphora*, from several localities in New South Wales. I have seen four specimens from Victoria, two females collected at Belgrave in December by myself, and two males taken at Belgrave in March and Millgrove in February by Mr. F. E. Wilson. The male, unknown previously, closely resembles the female except in the more slender abdominal petiole and in the antennae. Antennae reddish-yellow, becoming dusky toward apex, as long as the body; 13-jointed; scape long and slender; pedicel stout, hardly longer than wide; flagellar joints filiform, 1 two-thirds as long as the scape, 2 two-thirds as long as 1, a little excised on one side, 3—10 very gradually lengthening, but 10 is hardly as long as 1. As well as the Victorian examples I have collected four males in March at Scone, N.S.W.

ART. IV.—*Notes on the Jurassic Rocks of the Barrabool Hills,
near Geelong, Victoria.*

By ALAN COULSON, B.Sc.

(With Plate I.)

[Read 12th June, 1930; issued separately, 9th September, 1930.]

Introduction.

The Barrabool Hills comprise the fertile "rolling downs" agricultural country to the west of Geelong, between the townships of Highton (3 miles) and Gnarwarre (12 miles). The hills were once well timbered, but were cleared about 80 years ago, and are now remarkably bare and treeless.

Two east-flowing streams—the Barwon River and the Waurn Ponds Creek—drain the northern and southern faces of the hills, and their tributary creeks have carved the soft Jurassic sandstone into a series of rounded hills and spurs. The hills thus present the mature erosion topography characteristic of a region of slight relief.

Nature of the work done.

The map herewith shows for the first time the extent of Jurassic rocks in the Barrabool Hills. The eastern portion of the hills was included in Quarter Sheets 24 S.E. and 28 N.E. of the Geological Survey of Victoria, mapped by R. Daintree in 1861-2. Certain minor corrections have been made to this part, and the western portion has been added.

Dips were determined at every available outcrop, and the plotting of these led to the recognition of an unsuspected fault between the Jurassic basal beds and the normal sandstone beds.

Particular attention was given to the basal beds, where a fine series of conglomerates, sandstones, and fossiliferous mudstones is exposed in a river cliff on the Barwon, at the spot on the map marked "Basal Conglomerate." The collection of fossil flora obtained from the mudstone bands has clearly indicated the Lower Jurassic character of the basal beds.

Description of the Palaeozoic igneous rocks in the area has already been made (1), but the Kainozoic series has not yet been fully studied, and description of this is postponed. The debatable question of the origin of the Jurassic rocks is also deferred until more evidence is obtained.

Palaeontology.

A resumé of the recorded fossils from the Victorian Jurassic has been published by Mr. W. H. Ferguson (2). References to general geological and mining work on the Jurassic have been compiled by Prof. J. W. Gregory (3).

In the display cases at the National Museum, Melbourne, there are 3 specimens of Jurassic plants from the Barrabool Hills. These were presented by the Mines Department in 1903, and it is understood that Mr. (afterwards Sir) R. Daintree collected them while mapping Quarter Sheet 24 S.E. The forms are *Baiera subgracilis*, McCoy; *B. ipsviciensis*, Shirley; *Taeniopteris spatulata*, McClell. var. *Daintreei*, McCoy.

Mr. F. Chapman (4, p. 216) has recorded *Taeniopteris spatulata* McClell. var. *Daintreei*, McCoy, from Barrabool Hills.

Mr. G. B. Hope, of Geelong, has collected from a mudstone band in Queen's Park and the Newtown Brick pit nearby, the forms *Equisetites* sp.; *Sphenopteris maccoyi*, Sew.; *Taeniopteris spatulata*, McClell. var. *Daintreei*, McCoy; *Dictyophyllum* sp.; *Linguiofolium* sp.

From the fine grey mudstone intercalated with the basal boulder beds at the river cliff on the Barwon, I have collected numerous leaf impressions which Mr. R. A. Keble has identified as follow:—

EQUISETALES.

2. *Equisetites* sp.

FILICALES.

4. *Coniopteris hymenophylloides*, Brongn. var. *Australica*, Sew.
1. *Coniopteris* sp. (?)
27. *Sphenopteris ampla*, McCoy.
5. *Sphenopteris* sp.
7. *Taeniopteris spatulata*, McClell. var. *Daintreei*, McCoy.
5. *Taeniopteris spatulata*, var. *Carruthersi*, T. Woods.
2. *Cladophlebis denticulata*, Brongn. var. *Australis*, Morris.
1. *Taeniopteris crassinervis*, Feistl.
4. *Cladophlebis indica*, Old. and Morris.
1. *Cladophlebis* sp.
1. *Thinnfeldia* cf. *indica*, Feistl.
1. *Thinnfeldia* sp.
1. *Dictyophyllum* sp.

GINKGOALES.

2. *Ginkgo digitata*, McCoy var. *Huttoni*, Sew.
5. *Ginkgo* sp.
4. *Baiera Australis*, McCoy.

CONIFERALES.

3. *Araucaria* sp.
2. *Brachyphyllum Gippslandicum*, McCoy.
1. *Palissya* (?) sp.
1. *Cyparissidium* sp.

GYMNOSPERMAE.

2. *Carpolithes* sp.

Mr. Keble commented on the collection thus: "The flora is in many respects comparable with the *Sphenopteris ampla* beds from Archie's Creek (Chapman, F., Jurassic Plant Remains from Gippsland, *Rec. Geol. Surv. Vic.*, iii (2), p. 107), and Binginwarri (idem, p. 108). The *Ginkgo* and *Baiera* element suggests a lower

part of the series. There are 7 specimens of *Ginkgo* and 4 specimens of *Baiera*, and a number of indeterminate fragments of both genera, so that the Ginkgoales are relatively well represented. A single specimen of *B. australis* is recorded from one of the Binginwarri collections (idem, p. 108), in the same association, and similarly from Jumbunna (idem, p. 106), which shows that, while it is present, it is not a common form. The opinion is expressed here that the Barrabool Hills beds at Ceres are older than those at Binginwarri and Jumbunna. They are still apparently Jurassic, but the age of the underlying series is problematical, and we know by bores that there is a Mesozoic series at least 1500 feet thick at Jumbunna."

Only about 27 feet thickness of beds is exposed under the fossiliferous mudstone band, and from the structural features it is doubtful whether more than 100 feet of Jurassic would be passed through below that band before the bed-rock was met. There is little likelihood that the Jurassic series passes conformably downwards into beds of Lower Mesozoic age.

Lithology.

The Barrabool Hills rock is almost exclusively a brown felspathic sandstone (5, p. 190) of medium grain, with occasional thin bands of fine grey mudstone separating the thick sandstone beds. Near the base of the series the beds are coarser sandstones and grits. The conglomerates and boulder beds appear to be truly basal in position.

False bedding, carbonaceous laminae, small "clay pellets," and hard ovoidal indurations ("bullets") of calcareous matter, occur in the sandstone; these features are characteristic of the Victorian Jurassic. Small included fragments of slate (? Ordovician) are also common in the Barrabool sandstone.

Near Pollocksford, at the place marked on the map, "Gravel Conglomerate," there is a coarse grit, composed of rounded pebbles of quartz and slate fragments, interstratified with the normal sandstone beds.

The remarkable basal boulder beds and conglomerates are best seen on the face of the river cliff in the extreme south-eastern corner of the bend in the Barwon River, at the spot on the map marked "Basal Conglomerate." Talus obscures the beds elsewhere, but similar material can be traced to Buckley's Gorge about $\frac{1}{2}$ mile east of the river cliff.

Reading from the top of the cliff to the water level, the beds are:—

Sandstone and grit, normal type	63'
Conglomerate, type A	2'
Sandstone and grit, with slate inclusions	6'
Conglomerate, type B	2'
Sandstone, normal type	1'6"
Conglomerate, type B	0'6"
Sandstone, normal type	4'
Conglomerate, type B, smaller pebbles	1'

Sandstone, normal type	0'6"
Boulder bed, type C	20'
Mudstone, fine grey carbonaceous, with flakes of mica.	
Fossil bed	2'
Conglomerate, type B	0'3"
Mudstone, fine grey carbonaceous, as above	1'9"
Boulder bed, type C.	6'
Sandstone, normal type	16'
Grit, resembling arkose	2'6"
Conglomerate, type B, only partly visible	2'
<hr/>	
Total	131'0"

The distinction into types A, B and C among the conglomerates has been made because of differences in the size and nature of their pebbles. All the pebbles are waterworn and partly rounded, and are embedded in a matrix of much smaller pebbles and felspathic sand. Calcareous matter cements the whole, and has formed vertical veins of calcite through the beds.

The pebbles comprise: Heathcoteian green epidiorite, Lower Palaeozoic pink granite, Ordovician black slate, quartzite, spotted slate, Ordovician white quartz, grey mica schist, and Jurassic mudstone, sandstone and grit.

In type A conglomerate the Ordovician pebbles predominate, with fragments of Jurassic rock next in importance, and rare epidiorite and granite. The pebbles average about 2 in. diameter.

In conglomerate of type B the pebbles are about 4 in. in diameter, and consist of about equal amounts of epidiorite and Ordovician, with rare granite and Jurassic fragments.

Boulder bed C consists of pebbles in the same proportion as those of type B, but the boulders of epidiorite and granite are very large, up to 24 in. diameter.

The Ordovician material was identified by the discovery of graptolites in the slate pebbles by Mr. C. S. Wilkinson (6, p. 81).

Inclusion of fragments of Jurassic mudstone in Jurassic sandstone, etc., has also been recorded from South Gippsland (2, 7).

Structural Features.

Absence of Supposed Anticlinal Fold.

On Quarter Sheet 24 S.E. there is a line drawn in a N.E.-S.W. direction, roughly coincident with the course of the creek which meets the Barwon at the basal conglomerate cliff, and parallel to the section line AB of the present map, to indicate the axis of an anticlinal fold. Apparently the few dips shown on the Quarter Sheet furnished the evidence for this view, but the corrected dips fail to support the idea of an anticline. Actual folding of Jurassic strata has not been recorded in Victoria, and although the earlier workers, such as Daintree (8) and Wilkinson (9), represented folds in the sections they drew, more recent investigators, White-law (10), Ferguson (2, 7), and Dunn (11) attribute the changes of dip to faulting.

Basal Beds Fault.

In the area near the basal beds, there is a decided change of dip in the Jurassic beds; whereas the main block dips N.E. at about 10° , the basal beds have a strong dip of 30° to the South, almost directly opposed to this. The line of junction of the opposed dips runs E-W from Highton to the central epidiorite mass.

Two possible explanations of the opposed dips present themselves:—

- (i.) There may be an asymmetrical syncline.
- (ii.) Local sagging of the Jurassic along that line may have occurred, causing a fracture or fault between the two tilted blocks.

Insufficient outcrops are available to decide the point absolutely. Were the conglomerate beds constant and widespread, the fact that they do not reappear in the vicinity of Ceres township would be evidence against a syncline. But as with other Jurassic conglomerates, their horizontal distribution is very limited, and the beds probably "peter out" long before this. The second explanation, however, seems by analogy with other areas to be the more likely. Fig. 1 represents a section along the line ABC drawn in accordance with this view.

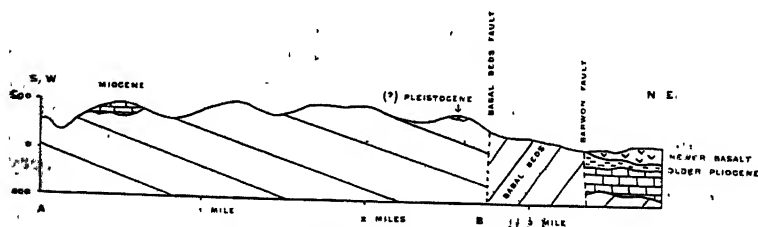
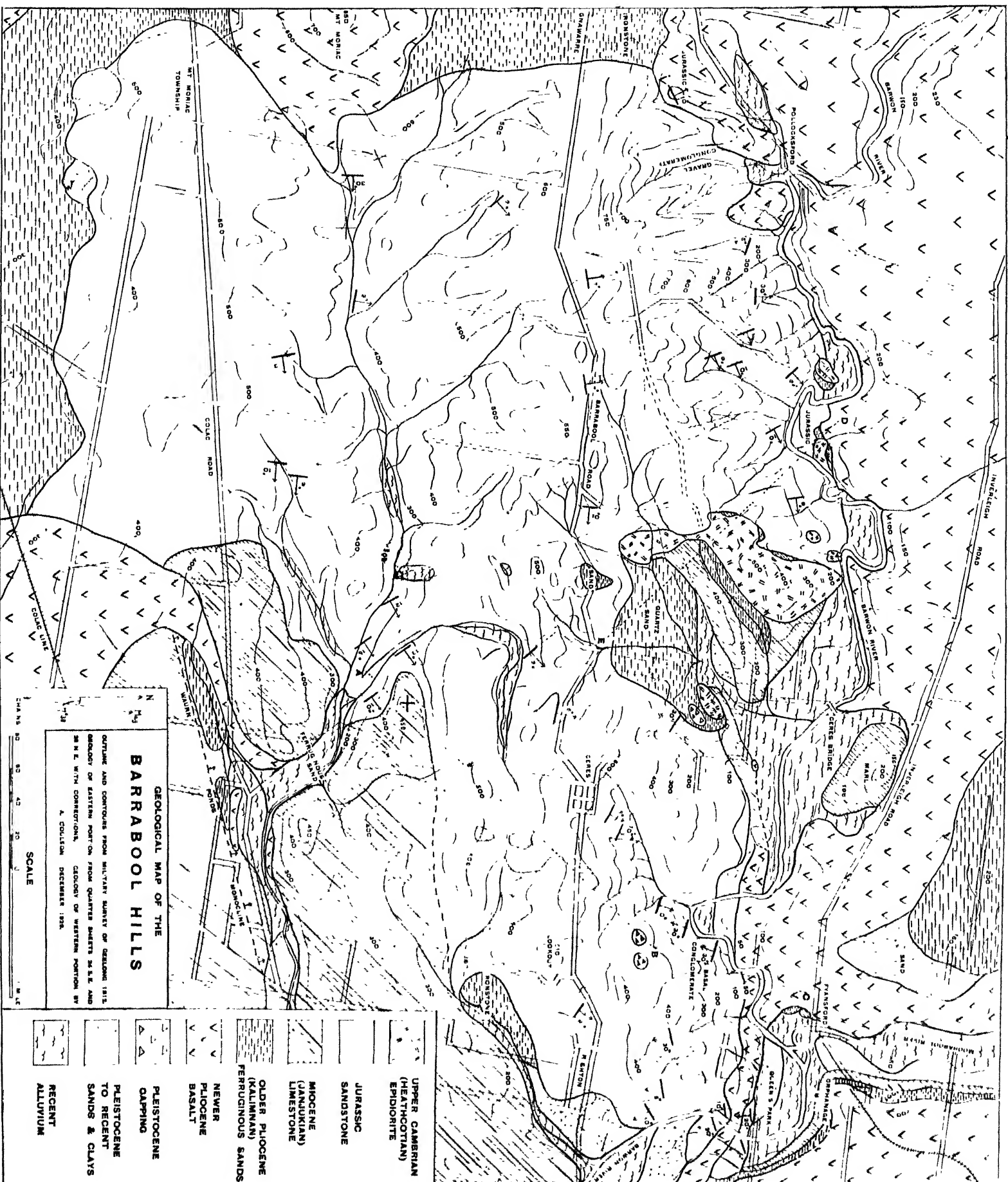


FIG. 1.—Sketch section along ABC.

Barwon Fault.

Topographic and geological evidence is available for this fault, which runs E-W along the northern face of the Barrabools coincident with the course of the Barwon River. The let-down block to the north of the hills consists of Kainozoic sediments overlain by Newer Basalt. Similar Kainozoic sediments capping the Jurassic on the southern upthrow side of the fault are considerably higher than those of the let-down block. For example, the Miocene limestone in the let-down block has not been bottomed by the Cement Company's bores at Batesford, although these reached 50 ft. below sea-level. The base of the same limestone in the upthrow block, alongside the central epidiorite mass, is 100 ft. above sea-level. This gives a minimum throw of 150 ft., but judging from the elevation of the fault scarp, the throw was of the order of 400 ft. This fault is shown in Fig. 2, a section drawn along the line DE.



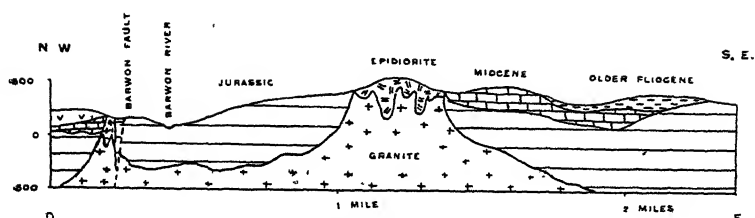


FIG. 2.—Sketch section along DE.

Acknowledgements.

To Mr. G. B. Hope, B.M.E., of Geelong, I am deeply indebted for his unfailing help throughout the work. For the identification of the fossils and his valuable comments thereon, I must thank Mr. R. A. Keble, F.G.S., palaeontologist to the National Museum. Messrs. E. D. Pridgeon, J. M. Edgar, and G. Baker have also assisted me in this and other work, and their help I would also like to acknowledge.

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ART. V.—*New and Remarkable Bees.*

By TARLTON RAYMENT.

[Read 10th July, 1930; issued separately 9th September, 1930.]

The late Mr. D. Best bequeathed the whole of his large collection of insects to the National Museum, Melbourne. The bees are not well represented, for the naturalist favoured other groups, but among them is a remarkable female, the label of which bore only the number "504." No information is available of either the locality of this specimen or the date when it was found. It is probable that as Mr. Best did little if any collecting beyond Victoria, the specimen is a native of this State.

Perkins (*Proc. Hawaiian Ent. Soc.*, ii, p. 29, 1908), described a unique male from the Violet Range, W.A., and seeing some affinity to the American genus *Pasiphae*, he erected the genus *Neopasiphae*, and named the species *mirabilis*. Since that time less than half a dozen males have been taken, at long intervals, but the female remained unknown. I was, therefore, very pleased indeed to find among Best's few honey-gatherers a new species of *Neopasiphae*, a female.

The second bee is no less remarkable since it, too, is the first to be added to another genus of Perkins. The genus *Ceratina* is well-known in America, and once more being impressed with its affinity to a bee which he collected at Bundaberg, Qld., he erected the genus *Neoceratina*, and named the species *australensis* (*Ann. Mag. Nat. Hist.* [8], xi, p. 117, 1912). No other specimen has been recorded, so it was interesting to find, among the unworked material, another *Neoceratina*, a female, collected by Mr. Charles Barrett at Townsville, Queensland, in August, 1920. Perkins describes his bee as having five segments in the maxillary palpus, as against six in *Ceratina*, but Barrett's specimen appears to have six segments, though the mouth-parts are not in good order, and I may be in error. I have been able to study these insects owing to the courtesy of the Director, Mr. J. A. Kershaw, and the Entomologist, Mr. J. Clark, of the National Museum, Melbourne.

Division COLLETIFORMES.

Family PROSOPIDIDAE.

NEOPASIPHAE INSIGNIS, sp. nov.

(Text-Fig. 1.)

Female.—Length, 10 mm. approx.

Head transverse, black, bright, with close puncturing of medium size; a few light brown hairs; face-marks are confined to the light clypeus and supraclipeal area; frons rough, subrugose owing to

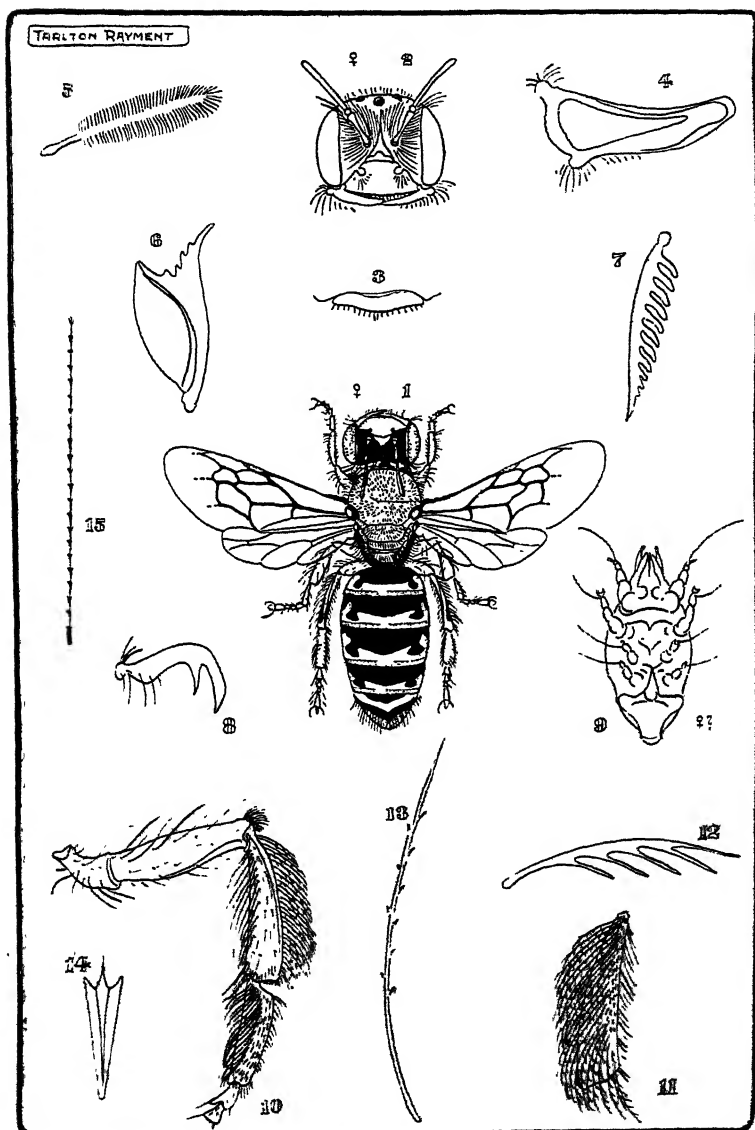


FIG. 1.

1. Adult female of *Neopasiphae insignis*, sp. nov. 2. Frontal view of head of female. 3. The labrum or lip is very narrow. 4. The jaw of the female is not notched, but is spoonlike. 5. One of the short stout plumose hairs of the mesothorax. 6. The strigil or antenna-cleaner is of *Frosopold* form. 7. The hind tibial spur is toothed like that of *Colletes*. 8. The claws are bifid, and the empodium large. 9. Acarid mite, ventral view, taken from hairs of this bee. 10. Inside surface of hind femur, tibia and tarsi. 11. Outside view of hind tibia, showing harvesting hairs. 12. Forked hair from tibia, highly magnified. 13. One of the long hairs of the femur. 14. A butterfly scale found on the bee. 15. A hair from the entanglement surrounding the mites.

the puncturing being pear-shaped, and not so close; clypeus creamy-yellow, large, bright, convex, two small black spots laterally, a cluster of creamy, plumose hairs below these, numerous punctures of medium size; supraclypeal area black, with a large, creamy-yellow patch, an exceedingly fine carina reaching the median ocellus, a few punctures and light hairs; vertex sharply developed; the rather large, brown ocelli being placed in a low curve; compound eyes of a yellowish brown colour, the anterior margins parallel; genae black, finely cancellate, a few light-brown hairs; labrum wide, but very shallow, yellow suffused with pale amber; mandibulae creamy-yellow, with amber margins and tips, no defined teeth; antennae submoniliform, black, the scape creamy-yellow beneath, the flagellum almost orange beneath.

Prothorax black, well developed, closely covered with punctures of medium size; tubercles black, but the hairs adjacent have been stuck together by immersion in some liquid; mesothorax black, dull, excessively punctured, with scattered, short, plumose hair; scutellum similar in colour and structure to mesothorax; postscutellum similar to scutellum, except that the punctures are longer; metathorax black, bright, a narrow lunate area, bounded by a rim, encloses a number of fine anastomosing rugae. Abdomen: dorsal segments, black, dull, excessively punctured, hind margins amber, creamy-yellow bands, broad laterally, with an indentation and a lobe; the marks resemble those of a European *Anthidium*. Ventral segments black, punctured, with amber margins.

Legs coxae, trochanters, and basal ends of femora, and inside surface of tibiae black, apical ends of femora, and outside surface of tibiae creamy yellow, anterior tibiae yellowish-amber, much golden hair. Tarsi: basitarsi broad, yellow; other tarsal joints short and amber-coloured; claws dark amber, bidentate, pulvillus large, reddish; velum convex; hind calcariae pale amber, with twelve strong teeth diminishing in size; tegulae amber, with yellowish patches and a tuft of hair; wings yellowish, prismatic, anterior measuring 8 mm. nervures clear ferruginous, the straight basal running beyond the nervulus, the two recurrents entering the second cubital cell at the ends. Cells: the two large cubitals are of equal size, the radial long, narrow and rounded on costa; pterostigma ferruginous, long and narrow; hamuli eleven in number, of moderate development.

Locality.—Probably Victoria. Best's label "510." Type in National Museum.

Allies.—This bee is clearly close to *N. mirabilis* Perkins, which was described from Western Australia, but the abdominal bands are of different shape.

Though no observations are available, the anatomical structure shows that the nest is a shaft in the ground, the cradle a skin cell laid down from the tongue, and the stores a stiff batter of honey and pollen formed into a ball. A few acarid mites were obtained from the fleece of this bee.

MEROGLOSSA MIRANDA, sp. nov. -

(Text-figs. 2 and 3.)

Male.—Length, 8 mm. approx.

Head narrow, of oily brightness, black, numerous punctures; face-marks dull cream-colour, acutely pointed above the insertion of the scapæ; frons with numerous punctures and a fine longitudinal carina reaching to the median ocellus; clypeus dull cream-colour, finely aciculate, anterior edge narrowly fulvous; supraclypeal area black, with a small transverse dull-cream mark; vertex with wine-pink ocelli in a triangle, facial foveae short and straight; compound eyes dark-brown, converging below; genae black, numerous punctures, long silvery hair; labrum oval, very pale-fulvous; the maxillary palpi being nearly twice the length of the antennae; mandibulae very pale amber, dark red apically; glossa short and pointed; antennae very long, scape stout, blackish above, fulvous beneath.

Prothorax black, a cream stripe, dilated at ends but interrupted in middle; tubercles cream colour; mesothorax black, bright, rough, with numerous punctures, a few white hairs posteriorly; scutellum and postscutellum similar to mesothorax, postscutellum with white hair; metathorax black, bright, a small area with slightly coarser sculpture; abdominal dorsal segments black, hind margins dull reddish, a fine cancellate sculpture, on one a short line of white hair laterally, a short fringe on all others.

Legs black, basal third of tibiae cream, also the knees, a few white hairs; tarsi fulvous, the basitarsi of hind legs cream; claws bifid, reddish; hind calcariae finely serrated, pale; tegulae fulvous posteriorly, cream anteriorly; wings hyaline, iridescent, anterior 5 mm.; nervures blackish-brown, basal slightly arched, second cubital receiving both recurrenents. Cells: second cubital slightly contracted at apex; pterostigma long, narrow, brownish; hamuli widely spaced, eight in number.

Locality.—Milly Milly station, West Australia (J. Glauert, 10th May, 1922). Type in the West Australian Museum.

Allies.—Not close to any described species. The exceedingly long palpi and the extraordinary abdominal processes distinguish it as one of the most remarkable bees yet described. It is very hairy for this genus.

EURYGLOSSA INCONSPICUA Ckll.

Ann. Mag. Nat. Hist. [8]. xii, p. 512, 1913.

Male.—Length, 5 mm. approx.

Head broad, not bright, a few short white hairs, obscurely greenish; face marks nil; frons with a minute sculpture; clypeus obscurely greenish, coarse scattered punctures, a minute sculpture, a few short white hairs; supraclypeal area similar to clypeus; vertex with tessellate pattern, and clear glassy ocelli; compound

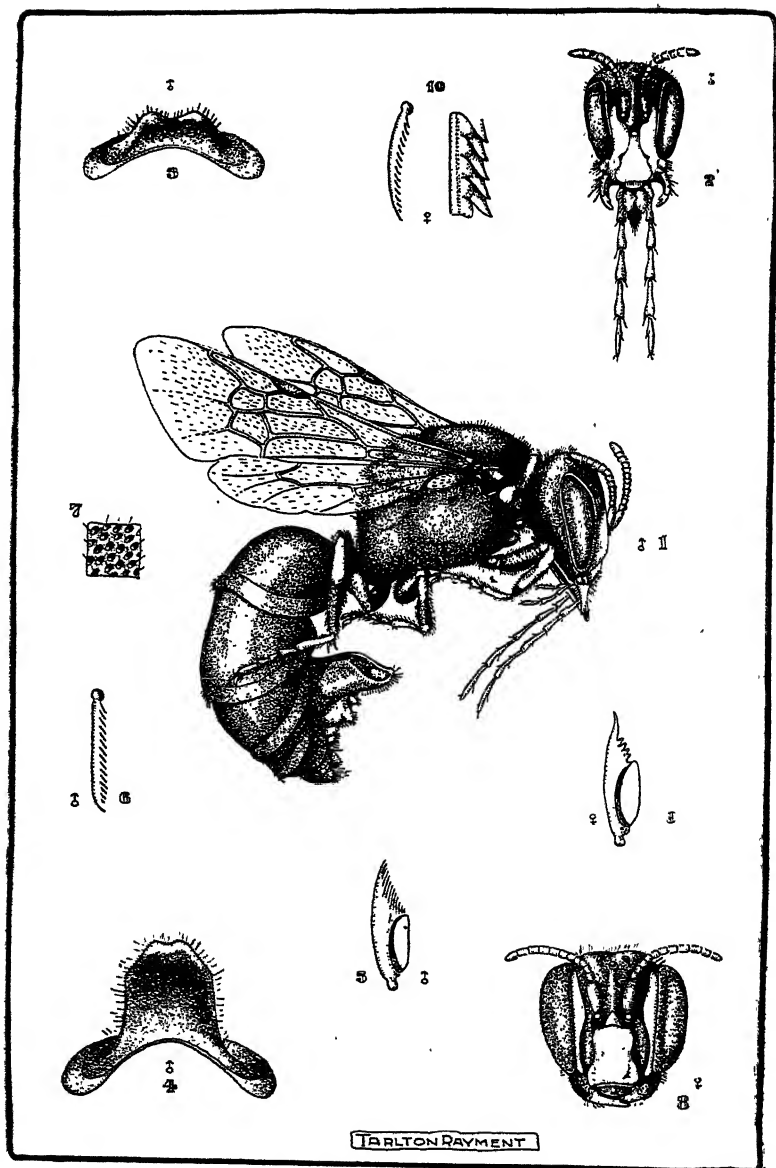


FIG. 2.

1. Adult male *Meroglossa miranda*, sp. nov. 2. Anterior view of head-capsule with the exceedingly long maxillary palpi extruded. 3. Nodose ridge on fourth ventral segment. 4. Posterior view of huge process on third ventral segment. 5. Strigil or antenna-cleaner of male. 6. Hind calcar or tibial spur. 7. Portion of the tegument of mesothorax. 8. Front view of head-capsule of female *M. impressifrons*. 9. Strigil of female. 10. Calcar of female, with serrations highly magnified.

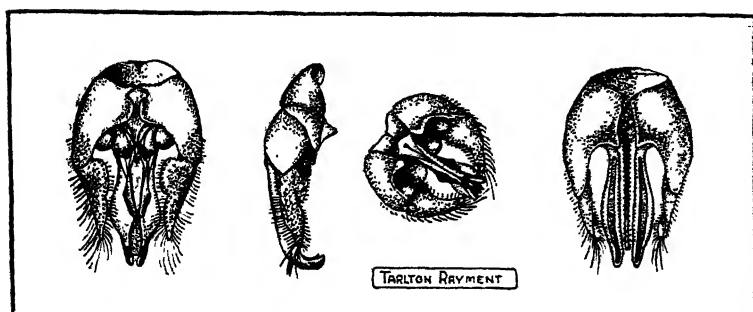


FIG. 3.

Four views, dorsal, lateral, oblique and ventral, of genitalia of *Meroglossa miranda*, sp. nov.

eyes blackish-claret; genae with a few stiff hairs; labrum black; mandibulae black at bases, reddish apically; antennae submoniliform, black.

Prothorax not visible from above; a fringe of long white hair surrounds the tubercles, black; mesothorax bright, dark bluish-green, with a minute tessellate sculpture, scattered punctures of medium size, a few dull-white hairs on disc; scutellum similar to mesothorax; postscutellum black, rough, a few long white hairs; metathorax black, bright, with a large area covered with a fine sculpture. Abdomen: dorsal segments black, polished, hind margins broadly but obscurely lighter, a finely lined transverse sculpture; ventral segments similar to dorsal surface.

Legs: coxae, trochanters femora, and hind tibiae black, knees and other tibiae light ferruginous, sparse long white hair; tarsi light ferruginous with white hair; claws reddish-amber; hind calcaria pale amber, finely serrated; tegulae dark ferruginous; wings hyaline, iridescent; nervures dark sepia, heavy, basal far short of nervulus; cells: the large second cubital is contracted at top; pterostigma dark sepia; hamuli few and weak.

Locality.—Sandringham, Port Phillip, Victoria (March, 1928, Rayment). Allotype in the National Museum.

The female was described from Purnong, South Australia.

Biological Data.—This may be called the Summer *Euryglossa*; one brood, consisting of both sexes, emerges during the hottest months. Nests are in the sandy loam, and the males hover over the burrows in great numbers. These bees visit the flowers of *Goodenia ovata*.

Division COLLETIFORMES.

Family COLLETIDAE.

PARACOLLETES PICTA, sp. nov.

Female.—Length, 11 mm. approx.

Head transverse, a brilliant blue-green with metallic irides-

cence; face-marks nil; there is a fairly dense covering of whitish plumose hair; frons highly polished, closely punctured, punctures somewhat pear-shaped; clypeus rather flat, polished, well-punctured; supraclypeal area similar to clypeus; vertex highly polished, very iridescent, densely and coarsely punctured, whitish hair; compound eyes claret-brown; genae densely covered with pear-shaped punctures, some long whitish plumose hair; labrum blackish; mandibulae dark amber; antennae submoniliform, beneath testaceous towards apex.

Prothorax just visible as a bright blue-green line; tubercles black, with a thick fringe of cinereous plumose hair; mesothorax polished blue-green, coarsely well-punctured, hair whitish at sides, but intermixed with black on disc; scutellum coloured like mesothorax, but punctures larger and closer, hair similar; postscutellum darker, finely granular, a tuft of whitish hair, small punctures; metathorax with small enclosed area highly polished and impunctate. Abdomen: dorsal segments brilliant bluish-green, highly polished, closely and coarsely punctured, hind margins narrowly brown, the anal fimbria of a brilliant golden orange; ventral segments of similar colour to dorsal surface, a few light and dark hairs.

Legs black or obscurely brownish, with pale plumose hair, floccus and scopa of a drab colour; tarsi fulvous beneath; claws reddish-amber; hind calcariae dark brown, with a number of long fine teeth; tegulae very dark, with only very obscure brownish tint; wings not entirely clear, iridescent, anterior 7 mm.; nervures dark sepia, radius rounded on costa, basal just short of nervulus; cells; cubitals contracted at top; first recurrent nervure entering second cubital cell at basal third, second recurrent entering third cubital at apical corner; pterostigma dark brown; hamuli of moderate development.

Locality.—Charleville, Queensland (G. F. Hill, 13th November, 1927). Type in the National Museum.

Allies.—Prof. Cockerell states this is close to *P. elegans* Smith, which is distinguished by ochreous hair at sides of thorax, lighter legs, and impunctate polished postscutellum.

PARACOLLETES MACULATUS, sp. nov.

(Text-fig. 4.)

Female.—Length, 10 mm. approx.

Head broad, black, bright, dull-white plumose hair; face-marks nil; frons rugose in middle, but finely granular at margins of orbits; clypeus prominent, scattered coarse punctures, polished, scattered whitish hair, a fringe of stiff fulvous hair; supraclypeal area similar to clypeus, but a fine carina rises to and surrounds the median ocellus; vertex finely granular, with wine-red ocelli in a curve; compound eyes blackish-claret, slightly converging below; genae rugose, with dull-white long plumose hair, but not well developed; labrum black; mandibulae black basally, reddish apically; antennae black, submoniliform.

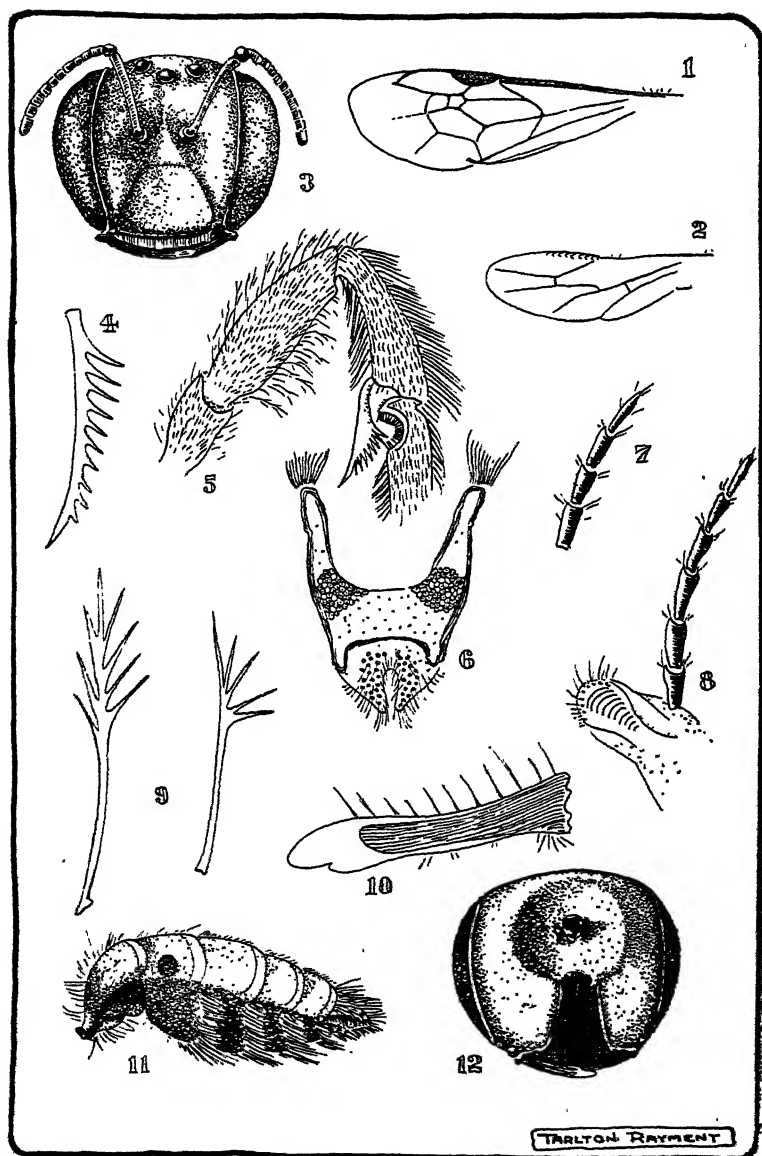


FIG 4.

1. Anterior wing of *Paracolletes maculatus*, sp. nov. 2. Posterior wing of female. 3. Front view of head-capsule of female. 4. Hind calcar of female. 5. Portion of anterior leg, showing the strigil or antennal scraper and antennal brush. 6. The apical dorsal segment of the abdomen. 7. Labial palpus has four segments. 8. Maxillary palpus has six segments. 9. Forked hairs from the legs of the female. 10. Mandible or jaw. 11. Lateral view of abdomen, showing the macula. 12. View of back of head-capsule of female.

Prothorax not visible from above; a fringe of drab-coloured hair surrounds the thorax; tubercles black, bright, a crescentic patch of light-drab short plumose hair; mesothorax black, bright, a minute tessellate pattern, scattered punctures of medium size, scattered hair of blackish tint on disc; scutellum similar to mesothorax; postscutellum dull, finely granular, black, a few long plumose drab-white hairs; metathorax black, bright, a very small lunate area with a few coarse converging rugae superimposed on a minute sculpture of tessellate pattern. Abdomen: dorsal segments red, sixth segment black, basal more or less blackish in some specimens, hind margins broadly darker, the second with a black spot at the sides, a few drab hairs laterally, a naked plate at apex; ventral segments; wider black bands, each fringed with drab hair.

Legs black, hind tibia with a flocus of beautiful plumose hair of drab tint; tarsi black, drab hair; claws reddish-amber; hind calcariae pale amber, with ten long spines gradated in size; tegulae polished black, with a fine tessellate pattern; wings sub-hyaline, iridescent, anterior 7 mm.; nervures dark ferruginous, second recurrent meeting third intercubitus, first recurrent entering second cubital cell at apical third; cells; second and third cubitals contracted at top; pterostigma dark amber; hamuli eight in number, of moderate development.

Male.—Length, 9 mm. approx.

Head black; wide, hair more ochreous than drab; face-marks nil, but granular sculpture becomes coarser at sides; frons with some anastomosing rugae; clypeus has close coarse puncturing and a minute sculpture, long plumose hair; supraclypeal area finely granular, a distinctive area; on the vertex the shafts of the hair are dark; compound eyes blackish claret; genae not well developed in this genus, slightly rugose, with drab plumose hair; labrum black, some specimens show obscure reddish tints; mandibulae black. The tongue is short and wide, of Colletid type; antennae submoniliform, black.

Prothorax not visible from above. A fringe of drab hair surrounds the thorax; tubercles black, and lack the fringe of the female; mesothorax black, finely granular, punctures difficult to find, the shafts of the hair being black; scutellum similar to mesothorax; postscutellum rough, black, hair with black shafts; a feature common to many bees of this genus; metathorax black, with a narrow lunate area enclosed by a fine rim, a few coarse irregular short rugae. Abdominal dorsal segments, basal black, red margin; all the others red, hind margins obscurely lighter; ventral segments red, with broad black margins.

Legs black, hair golden; tarsi black, hair more golden; claws reddish-amber; hind calcariae pale amber, finely serrated; tegulae polished black; wings sub-hyaline, iridescent, anterior 7 mm.; nervures dark amber, the basal being interstitial with nervulus; cells similar to those of female; pterostigma dark amber; hamuli seven in number, of moderate development.

Locality.—Sandringham, Port Phillip, Victoria (12th September, 1926, Rayment). Type (female) and allotype in the National Museum.

Allies.—Prof. Cockerell points out that this species is very close to *P. platycephalus* Ckll., *P. rufoaeneus* and *P. bimaculatus* Smith. The first-named was described from Windsor, Victoria. The palpi of the mouth parts are black, and it seems that a group could be separated on that character. In some New Zealand and Victorian *Paracolletes* the first recurrent nervure is absent, and the two discoidal cells are confluent.

The general appearance of this species is that of a red-bodied *Parasphicodes*.

Biological Data.—There is one brood, composed of both sexes, which emerges in spring. The larvae are carried over the winter, asleep in skin cells. They frequent, and mate on, the flowers of *Leucopogon richiei*, *Myoporum insulare* and *Cryptostemna calendulaceum*. The males are very active, and are much in evidence among the females on the plants specified. Copulation is effected on the flowers, and that is unusual with males of this genus.

ANDRENOPSIS WILSONI, sp. nov.

(Text-fig. 5.)

Male.—Length, 9 mm. approx.

Head broad, black, shining; tufts of white appressed hair at sides of clypeus; face-marks dull yellow; frons closely and coarsely punctured, producing a subrugose effect; clypeus shining, with a carina continued up beyond the supraclypeal area; a large amber mark roughly concavo-triangular, coarsely punctured; vertex with wine-pink ocelli, the numerous punctures producing a rugose appearance; compound eyes blackish-brown, almost parallel; genae well punctured, with long silvery plumose hair; labrum reddish; mandibulae amber, reddish apically, two strong teeth; antennae submoniliform, scape fulvous, first joint of flagellum black, others dark above, fulvous beneath, apical joint like a rounded chisel edge.

Prothorax not visible from above; tubercles black, fringed with white hair; mesothorax black, shining, coarsely and closely punctured; scutellum very wide, colour and sculpture of mesothorax; postscutellum triangular, posterior edge standing up sharply; metathorax very small, black, bright, roughened, a fringe of white hair, a rugose area is enclosed by a rim shaped like a Moorish arch, the apex reaching down the angle of truncation. Abdominal dorsal segments dull, closely punctured, ferruginous, a wide dark band on each segment, scattered short white hair; ventral segments ferruginous, with a scopa of white hair.

Legs ferruginous, coxae black, trochanters black, basal portion of hind femora dark, long white plumose hairs; tarsi clear chestnut-red; claws amber, reddish apically; hind calcaria pale amber,

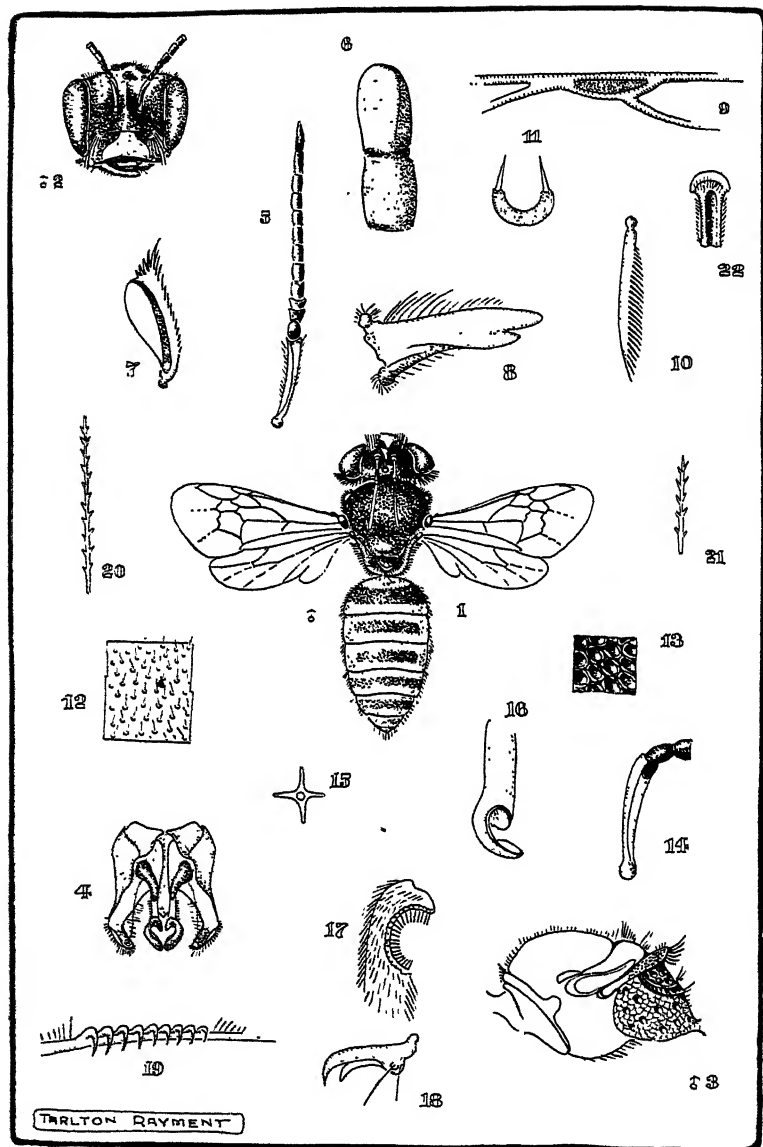


FIG. 5.

1. Adult male *Andrenopsis wilsoni*, sp. nov. (legs not shown). 2. Front view of head-capsule. 3. Lateral view of thorax to show sculpture of metathorax. 4. Genitalia. 5. Antenna. 6. The flattened apical segment of the flagellum. 7. Strigil of the anterior leg. 8. Mandible. 9. The pterostigma is surrounded with a nervure. 10. The hind calcar has long fine serrations. 11. Transverse section of calcar. 12. Portion of wing surface showing fine hairs. 13. Portion of tegment from mesothorax showing sculpture. 14. Apex of scape showing small cavity; compare with *Microglossa*. 15. A plumose hair viewed vertically. 16. Clasper from genitalia more highly magnified. 17. The antennal brush of the anterior leg. 18. One of the bifid claws. 19. The hamuli or wing-hooklets are of moderate strength. 20. Plumose hair from the gena or cheek. 21. Plumose hair from the abdomen. It will be noticed that these are Colletid bees, with only two cubital cells, and the plumosity of the body-hairs is very short. 22. The genitalia has a titillatum of the type of *Paracolletes*.

with long fine serrations fringing the thick rib; tegulae ferruginous; wings subhyaline, yellowish; anterior 6.5 mm.; nervures dark amber, basal arched and interstitial with nervulus, radius rounded on the costa, first recurrent entering second cubital cell at first third of its length; cells, the two cubitals equal, the second discoidal very large and pentagonal; pterostigma long, very narrow, sepia-coloured; hamuli, ten, of moderate development.

Locality.—Bogong High Plains (5000 ft.), Victoria (10th January, 1928, F. E. Wilson).

Allies.—The neururation of the wings is unusual, but the hairy covering is suggestive of the Colletid bees. While this description was in manuscript Professor Cockerell described the genus, and, consequently, this species is now added to it. This bee is very distinct from *A. flavorufus* Ckll. and *A. velutinus* Ckll. The first was described from Sydney, and the second from Kojarena, Western Australia, and this record adds the genus to the Victorian fauna.

PARACOLLETES RUFA, sp. nov.

(Text-fig. 6.)

Male.—Length, 11 mm. approx.

Head very wide, black, bright, a dense covering of long plumose golden hair; face-marks nil; frons shining and hollowed out; clypeus very convex, with numerous punctures of medium size. long hair; supraclypeal area similar to clypeus; vertex sharply developed, the wine-pink ocelli in a low curve; compound eyes claret-brown, inner orbital margins parallel; genae with long golden plumose hair; labrum reddish-brown; mandibulae long, reddish-amber, black basally and apically, one large tooth and a very small one; antennae with long hair on scape, flagellum almost subserrate, and articulated in such a way that a number of pore organs appear along the side.

Prothorax not visible from above; tubercles covered with dense long, golden hair; mesothorax black, bright, with numerous punctures of medium size, and a dense coat of long golden, beautifully plumose hair, there is a delicate sculpture; scutellum similar to mesothorax; postscutellum difficult to determine owing to the density of the long golden hair; metathorax covered with long plumose hair that hides all sculpture; abdominal dorsal segments clear chestnut red, with scattered long hair of dark colour; ventral segments lighter, with darker margins.

Legs: coxae, trochanters and basal half of femora brown. anterior femora and all tibiae ferruginous, with golden hair, the exterior of hind tibia having blackish hair; tarsi clear ferruginous; claws clear ferruginous; pulvilli black; hind calcariae amber, finely serrated; tegulae clear pale-amber; wings hyaline, iridescent, anterior 7 mm.; nervures dark-amber, first recurrent entering the second cubital at its middle. Cells: the second cubital slightly contracted at the apex, second and third cubitals subequal; pteros-

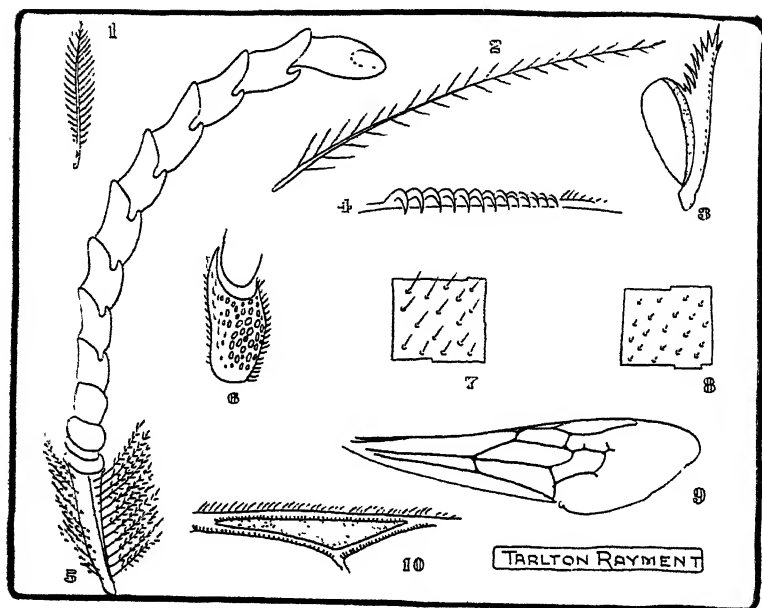


FIG. 6.

1. Small hair from thorax of *Paracolletes rufa*, sp. nov. 2. Long plumose hair from leg. 3. The strigil has fine spines; that of *Trichocolletes* coarse teeth. 4. Hamuli are well developed. 5. The segments of the flagellum are almost suberrate. 6. A segment more highly magnified to show pore organs. 7. Portion of membrane of wing (anterior). 8. Portion of membrane of wing (posterior). 9. The second and third intercubitus nervures of *Paracolletes* wing are often partly obsolete. 10. The pterostigma is surrounded with a nervure; compare with *Andrenopsis*.

tigma honey-coloured, not well developed; hamuli moderately developed.

Locality.—Purnong, South Australia (S. W. Fulton, 30th June, 1911). Type in the collection of the author.

Allies.—Not very close to any described species. It has a slight superficial resemblance to *Paracolletes fimbriatulus* Ckll., but is clearly distinct.

Division ANDRENIFORMES.

Family ANDRENIDAE.

Subfamily HALICTINAE.

HALICTUS DEMISSUS Ckll.

Proc. Acad. Nat. Sci. Philad., p. 371, 1916. ♀

Male.—Length, 6 mm. approx.

Head wide, black, not shining, a good covering of white plumose hair; face-marks nil; frons rough, hair shorter; clypeus prominent, hair longer and dense; on supraclypeal area hair not so

dense; vertex roughly lined, with clear glassy ocelli; compound eyes slightly converging about and below; genae black, with rough lines and a few plumose white hairs; labrum black; mandibulae black; antennae submoniliform, black, obscurely lighter beneath.

Prothorax not visible from above; tubercles with a few long white plumose hairs; mesothorax shining, obscurely greenish, scattered punctures of medium size, a fine tessellate sculpture, a few long white hairs; scutellum similar to mesothorax; postscutellum black; bright, rough; metathorax black, bright, a lunate area, not enclosed by a rim, with a few coarse radiating rugae superimposed on a minute sculpture. Abdominal dorsal segments polished, black, impunctate, minutely striate, except first, a few scattered white hairs; ventral segments similar to dorsal surface, hind margin of second lighter.

Legs slender, black, a few long white plumose hairs; tarsi dark amber with white hair; claws reddish; hind calcariae normal for male *Halictus*, i.e., finely serrate; tegulae light ferruginous; wings clear, iridescent, anterior 3.5 mm.

Nervures dilute sepia, second recurrent, and third intercubitus almost obsolete. Cells: second discoidal and third cubital confluent; pterostigma dark sepia; hamuli few and of weak development.

Locality.—Sandringham, Port Phillip, Victoria (Rayment, December, 1927). Allotype in National Museum, Melbourne.

Allies.—It seems to have some affinity to *H. inclinans*, Smith.

Biological Data.—Both sexes collected on flowers of Cauliflower, and the females are a little larger than the type which had previously been collected from Tasmania. There is a single brood composed of both sexes; the larvae are carried over the winter, but a rapid development takes place in Spring.

Division XYLOCOPIFORMES.

Family CERATINIDAE.

(Text-fig. 7.)

NEOCERATINA RUBINII, sp. nov.

Female.—Length, 7 mm. approx.

Head wide, colour dull orange, tegument bright, with numerous plumose white hairs of medium length; face-marks nil; frons suffused with black, bright, with numerous coarse punctures; clypeus convex, dull orange, coarse punctures, hidden by plumose white hair; supraclypeal area similar to clypeus; vertex roundly developed, coarsely punctured, but the dark suffused area does not extend to the orbital margins; compound eyes claret-brown, bulging, slightly converging below, numerous white, short, peglike hairs appear between the facets; an unusual character; genae conspicuous, with coarse punctures hidden by plumose white hair; labrum dull orange, rectangular; mandibulae reddish-brown,

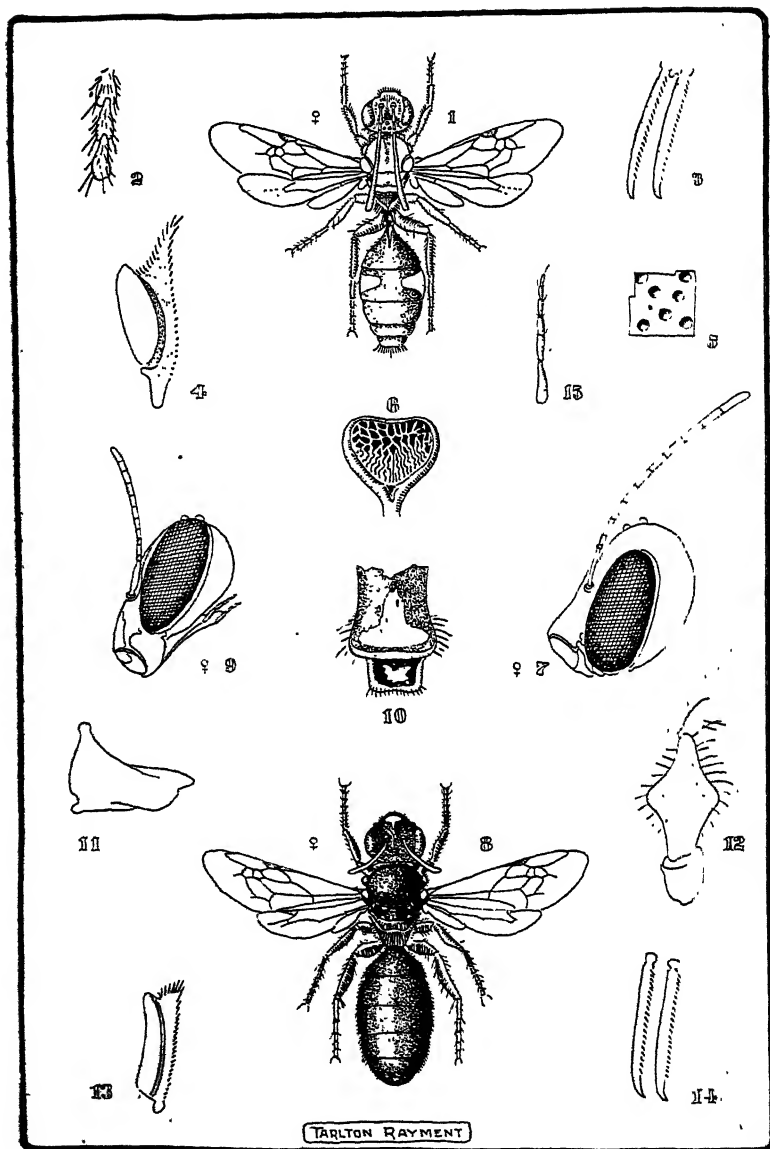


FIG. 7.

1. Adult female of Australian *Neoceratina rubinii*, sp. nov. 2. Tarsal segments from anterior leg. 3. The hind-tibial spurs are finely serrated. 4. The strigil or antenna-cleaner has an acute malus. 5. Portion of the tegument enlarged to show punctures. 6. The enclosed area of the meta-thorax is rugulose. 7. Lateral view of head, showing long antennae. 8. Adult female of American *Ceratina dupla* Say. 9. Lateral view of head, showing position of labrum. 10. Clypeus and labrum, showing cream markings. 11. The mandible or jaw is short and thick at base. 12. The femora are dilated. 13. Strigil has a short truncated malus. 14. The tibial spurs are characteristic of all bees that excavate and dwell in reeds.

spoonlike and short, with thick bases; antennae extremely long for a female, submoniliform, dull orange, extreme bases of scapes dark.

Prothorax dull orange, coarsely and densely punctured, bright; tubercles clear reddish-amber, polished, with a fringe of white plumose hair; mesothorax polished, reddish-amber, suffused down middle with black, many scattered punctures of large size; scutellum with sculpture like mesothorax, but colour lighter, bigibbous; postscutellum similar to scutellum; metathorax black, two obscure red patches laterally, a subtriangular area, enclosed with a fine rim, with coarse, anastomosing rugae basally, two pointed processes apically and laterally two dense patches of short white plumose hair; abdominal dorsal segments shining, rich reddish-amber, hind margins of five and six broadly lighter, two with deep-cream patch laterally, apex with a fringe of white hair; ventral segments much paler in colour.

Legs dull reddish orange, with scattered pale hair; tarsi paler; claws ferruginous; hind calcariae ferruginous, finely serrated, typical of reed-dwelling bees; tegulae clear, pale yellowish-amber; wings suffused with brownish colour and iridescent, very hairy, anterior 5 mm. Nervures dilute sepia, the first and third intercubitus much bent at apex, the basal straight, and running beyond the nervulus; cells: first cubital large, second and third cubitals small, subequal, contracted at apex; the radial cell rounded on the costa; pterostigma dilute sepia; hamuli seven in number, and of weak development.

Locality.—Townsville, Queensland (C. Barrett, August, 1920).

Allies.—Not close to the unique *N. australensis* Perkins, which has a white stripe on the clypeus, pallid spots on the tubercles, and a white stripe on the legs. I have not seen the genotype, but the neuration of the wings seems to agree.

Nothing is known of the life-history of these bees, but the anatomy of the creatures stamps them as reed-dwellers. Collected by Mr. Chas. Barrett. The species is dedicated to Jan Rubini, the musician.

Division APIFORMES (Social Bees).

Family APIDAE.

Subfamily MELIPONINAE.

TRIGONA COCKERELLI, sp. nov.

(Text-fig. 8.)

Worker.—Length, 5 mm. approx.

Head wide, bright, densely and finely punctured, with numerous appressed short white hairs, black; face-marks confined to a dull-white spot at the bases of the anterior orbital margins; frons large, with minute even puncturing, and appressed short white hair; clypeus similar to frons in sculpture, with a transverse dull white

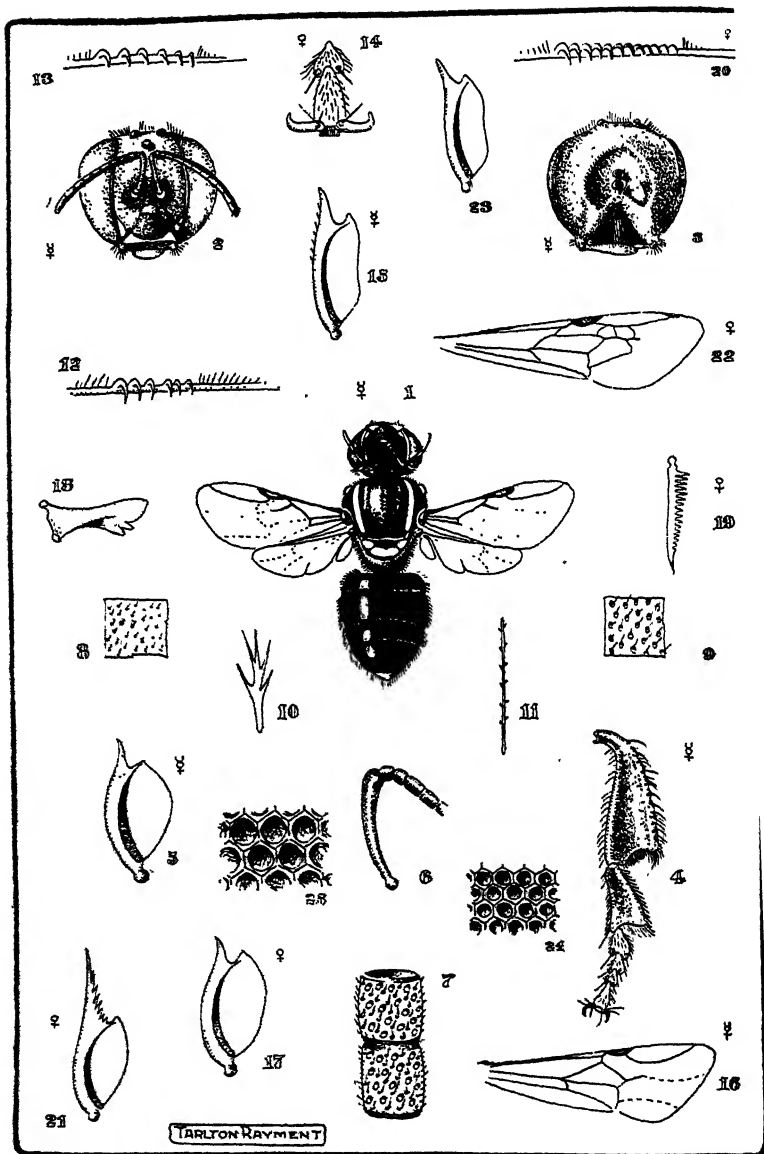


FIG. 8.

1. Adult worker of Australian social bee, *Trigona cockerelli*, sp. nov. (legs not shown). 2. Front view of head-capsule. 3. Posterior view of head-capsule of *T. carbonaria* Sm. 4. The hollowed tibia and tarsi of *T. Cockerelli*. 5. Strigil of the anterior leg. 6. Scape showing small cavity at apex; compare this with that of *Microglossa* Raym. 7. Segments of flagellum, showing pore and peg organs. 8. Minute hairs on wings. 9. The punctate sculpture of the mesothorax. 10. A forked hair from the face. 11. A fine plumose hair from the leg. 12. Hamuli or small wing-hooklets. 13. Hooklets from African social bee, *T. zebrae* Friese. 14. Claw segment of female (queen) *T. carbonaria* Sm. 15. Strigil of the South American social bee *T. capitata* Sm. 16. Anterior wing of the worker. 17. Strigil of female (queen) *T. carbonaria* Sm. 18. Mandibles of worker. 19. Hind tibial spur of South African Colletid bee. 20. Hamuli or wing-hooklets. 21. Strigil or antenna-cleaner. 22. The neurulation of the wing is of Colletid type. 23. Strigil of South African social bee, *T. denotti* Vachel. 24, 25. Cells of hive-bee *Apis* compared with those of *Trigona*.

median band which is dilated laterally into large triangular ends, convex; supraclypeal area with a wide, dull-white crescentic mark; vertex roundly developed, the clear glassy ocelli in a curve; compound eyes claret-brown, converging slightly at base and apex; genae with numerous short appressed white hairs; labrum dull-white; a distinct malar space; mandibulae black at bases, reddish apically, the median portion dull-white; antennae submoniliform, the scapes dull-white in front, flagellum fulvous beneath, dark above.

Prothorax black, not visible from above; tubercles cream, shaded to fulvous, a short fringe of white hair; mesothorax black, bright, with minute even puncturing, minute white hair, a narrow creamy stripe laterally from the prothorax to the scutellum; scutellum black, with a large cream dot laterally, and a large emarginate fulvous mark, a few long white hairs; postscutellum black, hidden; metathorax black, with a large scale-like sculpture, bright; abdominal dorsal segments highly polished, black, hind margins broadly reddish; ventral surface similar, with a whitish fringe on margins.

Legs black, with a whitish dot on median and anterior knees, and trochanters, the hind tibiae and basitarsi very broad and deeply concave on exterior surface, white hair; tarsi reddish-amber, with fulvous hair; claws reddish; empodium large; hind calcariae absent; tegulae dull, with drab patches and short white hair; wings hyaline, iridescent, anterior 3 mm.; the posterior with a large anal lobe; nervures pale-amber, basal arched and meeting nervulus, recurrents and intercubitals obsolete, only the basal stump of the cubitus being visible; cells: radial, long and narrow, the cubitals and discoidals are all confluent; pterostigma pale-amber, distinctly margined with a nervure; hamuli six in number, of weak development.

Locality.—Borrooloola, North Australia (Gerald Hill, 25th September, 1911). Type in the National Museum.

Allies.—*T. essingtoni* Ckll., which has a pale yellow mark, and two reddish-brown dots on clypeus, and a yellow scutellum; *T. cassiae* Ckll., which has different markings on clypeus and scutellum, and narrow lateral facemarks. The species is dedicated to Professor Cockerell, my mentor in Taxonomy.

Biological Data.—These social bees construct small horizontal brood-combs, the mouths of the cells being at the bottom. The honey-pots are large, and grouped on the circumference of the brood-combs; they are irregular spheres. The queen-larvae do not receive any "super-food," like those of *Apis*, but are reared solely on honey and pollen. Dr. Tillyard has stated that no social bee has a tibial spur, but it is present in *Bombus*, although wanting in the present genus. I have received a bee from the museum at Bulawayo, Africa, labelled "*Trigona beckeri* Friese. Id. Stevenson," but it is a Colletid bee; the wings and strigil are shown in the drawing.

A Correction.

In the immediately preceding issue of these Proceedings I erected the genus *Melitribus*. This was further discussed by me in the *Vic. Naturalist*, May, 1930, where I supplanted the genera *Stenotritus* and *Gastropsis*. I find my action is not in accordance with the rules of nomenclature and the law of priority. It is now definitely proved that the species contained in the genus *Gastropsis* are merely the males of the genus *Stenotritus*. The latter was founded some fifteen years before *Gastropsis*, and must, therefore, stand. Two well-defined groups are represented in the material at my disposal, and I therefore take this opportunity of correcting my error. Group 1 may be retained in Smith's genus *Stenotritus*, the species of which are tabulated below. Smith's description of *Stenotritus*, from an incomplete specimen, is so meagre that I did not regard it as sufficient; indeed, Smith himself had doubts about it. The following characters will serve to distinguish this genus:

Large hairy bees of dull metallic or submetallic green or yellow colour; the head wide; the ocelli well forward; the glossa short and wide; the paraglossae long; the second joint of the flagellum long; the females with a naked area on the apical segment the calcariae of the median and hind legs strongly toothed. The males smaller, very hairy, with a short shovel-shaped abdomen; the malus of the strigil double-curved, acute, very long; the velum being very short with a concave edge. The males have a superficial resemblance to *Anthophora*.

Stenotritus Smith.

Cat. Hym. Brit. Mus., p. 119, 1853.

Gastropsis Sm., Trans. Ent. Soc. Lond., p. xxxix, 1868.

Genotype, *S. elegans* Smith.

elegans Smith.

var. *A.* Ckll.

elegantior, Ckll.

glauerti, Raym. (*Melitribus*).

pubescens, Sm. (*Gastropsis*).

var. *nigrescens* Friese (*Gastropsis*).

var. *splendida* Raym. (*Gastropsis*).

smaragdinus Sm.

The remaining species I have retained in the genus *Melitribus*. These may be distinguished from *Stenotritus* as follows:—

Large black highly polished, but not metallic bees; the head circular; the compound eyes almost holoptic; the ocelli nearly at the level of the insertion of the antennae; the glossa short and wide; the paraglossa short; the second joint of the flagellum long; no naked area on abdomen, which is long and parallel-sided; the exceedingly thick malus of the strigil is truncated, and has a simple

curve; the velum being large and straight on the edge. The males have a superficial resemblance to *Megachile*.

Melitribus Rayment.

Proc. Roy. Soc. Vic., n.s., xlii (2), p. 217, 1930.

Genotype, *M. victoriae* Ckll.

greavesi Raym.

victoriae Ckll. (Gastropsis).

var. *rufocollaris* Ckll. (Gastropsis).

var. *A.* Ckll. (Gastropsis).

ART. VI.—*Catalogue of the Land Shells of Victoria.*

By C. J. GABRIEL.

(With Plates II, III.)

[Read 10th July, 1930; issued separately 11th September, 1930.]

Students of the Victorian Terrestrial Mollusca owe a great debt to the "Index to the Land Shells of Victoria," compiled by the late Dr. J. C. Cox and the late Mr. Charles Hedley, and published as Memoir No. 4 of the National Museum, Melbourne. Its excellent illustrations enable one to identify the various forms without difficulty. In some instances, however, the writer is a little at variance with their views, and the differences are noted in this communication. Little can be learnt of these forms without exhaustive study of specimens from different localities.

The work has been greatly facilitated by the privilege of examining the National Museum collection dealt with by Cox and Hedley. Much help has also been gained from specimens collected by Mr. F. L. Billingham and the late Mr. T. Worcester, both of whose land shell collections have passed into the hands of the writer. The late Mr. J. H. Young, of Meredith, was an indefatigable collector, and his untimely death removed a keen observer of these forms. Thanks to the zeal and activity of these and other naturalists, the total since Cox and Hedley's Index has been considerably increased, notwithstanding the reputed paucity of our Land Shell fauna.

This catalogue records 45 species and 2 varieties, including 8 new species. The synonymy of each appears, but it has been the aim of the writer to refer to a generic change, or perhaps to a record of some distant locality rather than to supply every available reference. It is probable that a fair number of additions will be made when the whole State is thoroughly explored. In fact, the writer is in possession of several apparently new forms, but with single specimens only it is considered advisable to postpone description until further examples appear. I now take the opportunity of expressing my indebtedness to Mr. J. Clark for the careful execution of the figures. The types of the new species are in the collection of the writer.

Family PUPILLIDAE.

Sub-Family PUPILLINAE.

Genus *Pupilla*, Leach, 1820.

PUPILLA AUSTRALIS, Adams and Angas.

1863. *Vertigo australis*, Adams and Angas, P.Z.S. Lond., p. 522.
1864. *Pupa nelsoni*, Cox, Cat. Aust. Land Shells, p. 29.
1867. *Pupa lincolniensis*, Cox, P.Z.S. Lond., p. 39.

1868. *Pupa australis*, Ad. and Ang. Cox, Mon. Aust. Land Shells, p. 79.
 1868. *Pupa lincolniensis*, Cox, Mon. Aust. Land Shells, p. 80, pl. 14, fig. 16.
 1868. *Pupa nelsoni*, Cox, Mon. Aust. Land Shells, p. 79, pl. 14, figs. 19, 19a.
 1878. *Pupa lincolniensis*, Cox. Sowerby, Conch. Icon, xx (Pupa), pl. 11, fig. 104.
 1883. *Pupa tasmanica*, Johnston, P.R.S. Tas. for 1882, p. 144, pl. 1.
 1895. *Pupa lincolniensis*, Cox. Smith, P. Mal. Soc. Lond., i, p. 96.
 1896. *Pupa australis*, Ad. and Ang. Tate, Horn Exped. Zool., p. 205.
 1909. *Vertigo lincolniensis*, Cox. Petterd and Hedley, Rec. Aust. Mus., vii (4), p. 283.
 1916. *Vertigo lincolniensis*, Cox. Hedley, J.R.S. W. Aust., i (for 1914-15), p. 68.
 1921. *Pupilla australis*, Angas. Pilsbry, Man. Conch. [2], xxvi, p. 218, pl. 23, figs. 13-19.
 1921. *Vertigo lincolniensis*, Cox. May, Check-List Moll. Tas., p. 91, No. 891.
 1923. *Vertigo lincolniensis*, Cox. May, Ill. Index Tas. Shells, pl. 42, fig. 1.

Size of Type.—Length, 4.23; breadth, 1.58 mm.

Localities.—Irymple (J. H. Young); Natya (C. Oke); Cape Bridgewater (W. H. Dillon); Bannerton (A. C. Nilson); Frankston.

Obs.—A sinistral form, showing much variation. The author remarks: "A cylindrical and, for the genus, a large species, with the aperture furnished with but two plicae." Johnston states: "The name *P. tasmanica*, first given to the shell, has been withdrawn, as on comparison with *P. lincolniensis* Angas, I found that the Tasmanian form was not specifically distinct from it." Dr. Pilsbry (loc. cit.) notes: "Typically rather coarsely striate, but this is individually variable in my specimens, embryonic whorls are irregularly, densely, but shallowly pitted. Aperture shows an angular nodule connected with the termination of the lip (sometimes nearly obsolete)." In regarding these four species as synonymous, the writer concurs in the decision arrived at by Dr. Pilsbry, and, further, it appears to be more happily placed in the genus *Pupilla*. E. A. Smith recorded *P. lincolniensis* from Pigeon Island, near Wallaby Island (Dr. Richardson in Brit. Mus.), and East Wallaby Island, Houtman's Abrolhos (Walker). He remarks: "The specimens collected by Dr. Richardson and Mr. Walker have a second basal tubercle as indicated in Cox's figure, and a third far within upon the columella. It is possible that in the examples examined by Dr. Cox, the denticles were only feebly developed, or they may even have been overlooked, being rather indistinct." This addition to our fauna provides an interesting distribution, being located in New South Wales, Victoria, South Australia, Western Australia and Tasmania.

The type was obtained at Rapid Bay, South Australia, in crevices of rocks.

Family PUPIDAE.

Genus *Bifidaria*, Sterki, 1889.*BIFIDARIA BANNERTONENSIS*, sp. nov. (Pl. III, Figs. 9, 10).

Shell minute, white, dextral, attenuate, narrowly umbilicate. Apex obtuse. Whorls five, convex, ornamented by numerous oblique growth-striae. Sutures deeply impressed. Aperture roundly oblong, armed with five white teeth; one situated about the centre of parietal wall, comparatively large and unequally bifid; three placed within the basal and outer margin, the centre of which is the most prominent; the fifth on the columella. Peristome expanded, the columellar expansion partly concealing the narrow umbilicus.

Size of Type.—Length, 2·6; breadth, 1·3 mm.

Locality.—Bannerton (A. C. Nilson).

Obs.—Few species have been described from Australia, and the present is the first representation of the genus in Victoria. In general arrangement the dentition is fairly constant, but specimens have been examined showing the teeth a trifle stronger. As regards measurements, the species is subject to variation, the paratype figured being 2·3 x 1 mm. *Pupa larapinta*, Tate, and *P. mooreana*, Smith, from Central Australia, bear some resemblance, but may be distinguished by their broader contour and more convex whorls.

Genus *Pupoides*, Pfeiffer, 1854.*PUPOIDES ADELAIDAE*, Adams and Angas.

- 1863. *Buliminus* (*Chondrula*) *adelaidae*, Ad. and Ang., P.Z.S. Lond., p. 522.
- 1864. *Pupa ramsayi*, Cox, Cat. Aust. Land Shells, p. 28.
- 1868. *Bulimus adelaidae*, Ad. and Ang. Cox, Mon. Aust. Land Shells, p. 69, pl. 13, fig. 5.
- 1889. *Bulimus* (*Chondrula*) *adelaidae*, Ad. and Ang. Cox, P.L.S. N.S.W. [2], iii (for 1888), p. 1254.
- 1896. *Buliminus adelaidae*, Ad. and Ang. Mulder, Geelong Nat., v (4), p. 7.
- 1900. *Pupoides adelaidae*, Ad. and Ang. Pilsbry, Proc. Ac. Nat. Sci. Phil., p. 428.
- 1921. Id., Pilsbry, Man. Conch. [2], xxvi, p. 140, pl. 15, figs. 1, 2.

Size of Type.—Length, 6·34; breadth, 2·11 mm.

Localities.—Irymple (J. H. Young); Sea Lake, Mallee (J. C. Goudie); Bannerton (A. C. Nilson); Geelong (Mulder).

Obs.—A form readily recognised. E. A. Smith suggests that his species *Pupa contraria*, from East Wallaby Is., W.A., may prove to be a sinistral form of *P. adelaidae*, Ad. and Ang. Tate, in the Zoology of the Horn Expedition, p. 204, disagrees, remarking that it differs conspicuously by its pyramidal outline. With specimens collected under stones by C. W. Musson, it is recorded from Little Mountain, Narrabri, N.S.W., by Dr. Cox (loc. cit.). The present record, with those of the neighbouring States, proves this to be a widely distributed species. The Type was collected in South Australia.

PUPOIDES ISCHNUS, Tate.

1894. Pupa ischna, Tate, T.R.S.S.A., xviii, p. 191.

1896. Id., Horn Exped. Zool., p. 204, pl. 19, figs. 16a,b.

1900. Pupoides ischnus, Tate, Pilsbry, Proc. Ac. Nat. Sci. Phil., p. 428.

1921. Id., Pilsbry, Man. Conch. [2], xxvi, p. 146, pl. 15, figs. 3, 4.

Size of Type.—Length, 4.25; breadth, 1.25 mm.

Localities.—Irymple (J. H. Young); Bannerton (A. C. Nilson).

Obs.—A sinistral form, hitherto unrecorded from Victoria, compared with co-types from the late W. T. Bednall's collection. The author's observations are: "A more slender shell and more attenuate apically than *P. contraria*; in its sinistral spire and apertural characters it agrees with *P. myoporinae*, Tate, which is possibly only a sinistral form of *P. pacifica*, from which it differs in its narrow elongate shape and flatter whorls. It may prove on comparison of actual specimens conspecific with *Chondrula lepidula*, Ad. and Ang."

Type from Central Australia.

Family SUCCINEIDAE.

Genus *Succinea*, Draparnaud, 1801.

SUCCINEA AUSTRALIS, Ferussac.

1821. *Succinea australis*, Fer., Tabl. Syst., ii, p. 27.

1825. Id., Gray, Ann. Phil., p. 415, pl. 9.

— Id., Fer. and Desh., Hist. Nat. Moll. Terr. et Fluv., ii (2), p. 137, pl. 11, fig. 11.

1832. Id., Quoy and Gaimard, Voy. Astrolabe, Zool., Moll., ii, p. 150, pl. 13, figs. 19-23.

1868. Id., Cox, Mon. Aust. Land Shells, p. 88, pl. 15, figs. 7, 7a.

1871. *Succinea legrandi*, Cox, in Legrand Coll. Mon., sp. 2.1873. *Succinea australis*, Fer. Reeve, Conch. Icon., pl. 9, fig. 59.1882. *Succinea australis*, Fer. Tate, T.R.S.S.A., iv, p. 75.

1893. Id., Billingham, Vic. Nat., x, p. 62.

1909. Id., Petterd and Hedley, Rec. Aust. Mus., vii, p. 283.

1912. Id., Cox and Hedley, Mem. Nat. Mus. Melb., No. 4, p. 6.

1921. Id., May, Check-List Moll. Tas., p. 91, No. 892.

1923. Id., May, Ill. Index Tas. Shells, pl. 42, fig. 2.

Size of Average Specimen.—Length, 12; breadth, 7 mm.

Localities.—Western Port (Astrolabe); Melbourne (Petterd); Castlemaine and Harcourt (Billingham); Timboon (H. W. Davey); Frankston and Wimmera District (Kershaw); You Yangs (C. L. Barrett); Yarraby; Cape Nelson; Tarraville; Mornington (Rev. G. Cox); Dartmoor.

Obs.—Petterd and Hedley (loc. cit.) remark: "We consider this to be the shell usually called *Succinea strigata*, Pfr., originally described from Port Clarence, Behring Strait. The localities for the types of *S. australis* are Kangaroo Island and the Isles of St. Peter and St. Francis, in South Australia." This is one of the commonest of our Land Shells. They are not confined to

the ground, being frequently located beneath the bark of tree-trunks. The species is widely distributed throughout Victoria and Tasmania.

SUCCINEA AUSTRALIS, Fer., var. QUEENBOROUGHENSIS, Petterd.

1879. *Succinea australis*, Fer., var. *queenboroughensis*, Petterd, Mon. Tas. Land Shells, p. 49.

Size of Type.—Length, 11.5; breadth, 8 mm.

Locality.—Frankston (T. Worcester).

Obs.—Compared with Tasmanian specimens in the Hobart Museum, from Brown's River road.

Family ACAVIDAE.

Genus *Hedleyella*, Iredale, 1914.

HEDLEYELLA ATOMATA, Gray, var. KERSHAWI, Brazier. (Pl. III, Figs. 1-8).

1871. *Bulimus* (*Liparus*) *kershawi*, Brazier, P.Z.S. Lond., p. 641.

1882. Id., Tate, T.R.S.S.A., iv, p. 75.

1892. *Panda atomata*, var. *kershawi*, Braz., Hedley, Rec. Aust. Mus., ii, p. 31, pl. 5, fig. 9.

1912. Id., Cox and Hedley, Mem. Nat. Mus. Melb., No. 4, p. 6.

1892. Id., Pilsbry, Man. Conch., viii, p. 293.

1894. Id., Pils., Man. Conch., ix, p. 164.

1900. Id., Pils., Man. Conch., xiii, p. 122, pl. 5, fig. 84.

Size of Type.—Length, 50.79; breadth, 28.56; alt., 25.39. Aperture: Length, 31.73; breadth, 15.86 mm.

Localities.—Snowy River, Gippsland (W. Kershaw); Nowa Nowa (self).

Obs.—Iredale, when proposing *Hedleyella*, states that *Panda*, Albers, is invalid through preoccupation. Four species constitute the genus in Australia, and, as the author remarks, it comprises the most interesting and magnificent land shells of our country. This, the largest of the Victorian land forms, apparently is confined to the eastern portion, and as noted by Hedley, "No habitat has been recorded for this form between the valleys of the Hunter and of the Snowy River. Yet, despite their geographical isolation, southern specimens can be precisely matched, as Dr. Cox has kindly demonstrated to me, by northern shells." The writer's observations agree entirely with Pilsbry, Cox and Hedley's treatment in regarding *kershawi* as a variety only. Many specimens in Victorian collections have been examined, and, as evidenced in the figures of Plate III, show extreme variation in contour. The coloration, likewise, is very variable. Brazier, in his description of *kershawi*, remarks that "it approaches in appearance to *B. larreyi*, Braz., and *B. atomatus*, Gray. It differs from those species in not having the dark spots and zig-zag lines that are so characteristic in them." Mr. Hedley has separated three forms of *atomata* as varieties—*azonata*, *tigris*, *elongata*.

Family HELICIDAE.

Genus *Chloritis*, Beck, 1837.*CHLORITIS VICTORIAE*, Cox.

1868. *Helix victoriae*, Cox, Mon. Aust. Land Shells, p. 37, pl. 12, fig. 5.
 1882. Id., Tate, T.R.S.S.A., iv, p. 75.
 1888. *Helix brunonia*, Johnston, P.R.S. Tas., for 1887, p. 75.
 1890. *Helix victoriae*, Cox. Tryon, Man. Conch., vi, p. 149.
 1909. *Chloritis brunonia*, Johnston. Petterd and Hedley, Rec. Aust. Mus., vii (4), p. 285, pl. 82, figs. 2-4.
 1912. *Chloritis victoriae*, Cox. Cox and Hedley, Mem. Nat. Mus. Melb., No. 4, p. 6, pl. 1, figs. 1, 2.
 1921. Id., May, Check-List Moll. Tas., p. 91, No. 896.
 1923. Id., May, Ill. Index Tas. Shells, pl. 42, fig. 6.

Size of Type.—Maj. diam., 15.99; min., 12.69; alt., 11.42 mm.

Localities.—Western Port (type locality, Masters and Petterd); Jan Juc (Kershaw); Forrest (Steel); Cape Otway (Petterd); Torquay (Miss E. Gatliff); Millgrove (C. L. Barrett); Lorne, Grampians, Whitfield (self); Wartook; Dartmoor; Frankston.

Obs.—This is a very common and widely distributed species throughout Victoria. Beyond the State it is recorded from King Island and Mt. Kosciusko. Normally the shell is of a uniform brown colour, but a specimen before me, collected at Millgrove by Mr. Barrett, is almost colourless, although in perfect condition. A favourite haunt of this species is under charred timber and tree-fern trunks. When deprived of its characteristic bristly epidermis, it alters in general appearance, and is suggestive of another species.

CHLORITIS BREVIPILA, Pfeiffer.

1850. *Helix brevipila*, Pfeiffer, P.Z.S. Lond., for 1849, p. 130.
 1854. Id., Reeve, Conch. Icon., vii, pl. 128, fig. 777.
 1864. Id., Cox, Cat. Aust. Land Shells, p. 6.
 1868. Id., Cox, Mon. Aust. Land Shells, p. 47, pl. 5, figs. 2a,b.
 1888. Id., Hedley, P.R.S. Qld., v (2), p. 54.
 1890. *Helix (Chloritis) brevipila*, Pfr. Pilsbry, Man. Conch., vi, p. 265, pl. 58, figs. 28-30.
 1896. *Chloritis brevipila*, Pfr. Hedley, Rec. Aust. Mus., ii, p. 105.
 1906. Id., Gude, P. Mal. Soc. Lond., vii, pp. 48, 114, pl. 4, fig. 9.

Size of Type.—Maj. diam., 12; min., 10; alt., 6.5 mm.

Locality.—Victoria (Kershaw, Gude).

Obs.—Recalling the preceding species, but with sparser bristles. Gude (loc. cit.) discusses the genus *Chloritis*, describing among other forms two from New South Wales, *C. novacambica* and *C. disjuncta*. The former is "similar in shape to *C. brevipila*, but twice the size, and with the hairs much more crowded," while the latter is "smaller, the spire more elevated, the umbilicus slightly narrower, and not excavated or angulated, and the hair-scars more crowded." Outside of Victoria it is recorded by Gude from S. Australia, N.S. Wales, Queensland, and islands in Torres Straits.

Genus *Thersites*, Pfeiffer, 1855.*Thersites jervisensis*, Quoy and Gaimard.

1832. *Helix jervisensis*, Quoy and Gaimard, Voy. Astrolabe, Zool., Moll., ii, p. 126, pl. 10, figs. 18-21.
 1847. Id., Pfeiffer, Mon. *Helix*, i, p. 79.
 1854. Id., Reeve, Conch. Icon., pl. 126, fig. 758.
 1868. Id., Cox, Mon. Aust. Land Shells, p. 30, pl. 1, figs. 2, 2a.
 1890. Id., Pilsbry, Man. Conch., vi, p. 141, pl. 40, figs. 90, 91.
 1892. Id., Pils., Man. Conch., viii, p. 281.
 1894. *Thersites jervisensis*, Q. and G. Pilsbry, Man. Conch., ix, p. 131.
 1925. Id., Gabriel, Vict. Nat., xlii (8), p. 207.

Size of Type.—Diam., 19.04; alt., 12.69 mm.

Locality.—On a hill-slope near Stony Creek (tributary of Genoa River) (C. L. Barrett).

Obs.—On a single specimen this was added to our fauna by the writer in 1925. With such well-executed figures by the authors one may readily identify the species. A useful recognition mark is the carination on the body-whorl. Pilsbry (loc. cit., page 281), states: "The synonymy of the *grayi* type of shells is believed by my friend, Dr. Cox, to be as follows: *H. jervisensis*, Q. and G. 1832; *H. gilberti*, Pfr., 1845; *H. grayi*, Pfr., 1848; *H. exocarpi*, Cox, 1868; *H. bednalli*, Braz., 1871. I am in full agreement with this synonymy. Dr. Cox also suggests that the lighter, thinner forms, *corneovirens*, Pfr., 1851, and *mulgoae*, Cox, 1868, may prove to fall into this species." The question is further discussed by Cockerell in the British Journal of Conchology, xviii, p. 321.

Thersites fodinalis, Tate.

1892. *Helix* (*Hadra*) *fodinalis*, Tate, T.R.S.S.A., xvi, p. 63, pl. 1, figs. 1a-1c.
 1892. *Hadra fodinalis*, Tate. Pilsbry, Man. Conch., viii, p. 277, pl. 58, figs. 2, 3, 4.
 1894. *Thersites fodinalis*, Tate, Pils., Man. Conch., ix, p. 131.
 1896. *Thersites* (*Badistes*) *fodinalis*, Tate, Horn Exped. Zool., p. 199.
 1896. *Xanthomelon fodinalis*, Tate Hedley, Horn Exped. Zool. (Appendix), p. 223, figs. in text, G, H, I (anatomy).

Size of Type.—Maj. diam., 18; min., 15; alt., 14.25 mm.

Locality.—Yarrara, N.W. Victoria (Nat. Mus. Melb.), collected by Mrs. L. J. Collard.

Obs.—A moderately umbilicated species, with its surface coarsely and closely wrinkled, transversely. Hitherto unrecorded for Victoria. It appears to be common in S. Australia, the author remarking: "This is by far the most widely-spread and abundant snail over the region explored by the Horn Expedition."

Family RHYTIDIDAE.

Genus *Rhytida*, Albers, 1860.*RHYTIDA LAMPRA*, Reeve.

1854. *Helix lampra*, Reeve, *Conch. Icon.*, vii, pl. 186, fig. 1295.
 1855. Id., Pfeiffer, *P.Z.S. Lond.*, for 1854, p. 53.
 1868. Id., Cox, *Mon. Aust. Land Shells*, p. 28, pl. 10, fig. 9.
 1873. *Rhytida lampra*, Pfr. Crosse and Fischer, *J. de Conch.*, p. 19.
 1885. Id., Tryon, *Man. Conch.*, i, p. 125, pl. 23, fig. 29.
 1892. Id., Hedley, *P.L.S. N.S.W.* [2], vi, p. 23, pl. 2, figs. 8, 9, pl. 3, fig. 3.
 1905. *Rhytida (Eurhytida) lampra*, Pfr. Moellendorff and Kobelt, *Conch. Cab. (Agnatha)*, p. 28, pl. 5, figs. 4-7.
 1909. *Rhytida lampra*, Reeve. Petterd and Hedley, *Rec. Aust. Mus.*, vii, p. 286.
 1921. Id., May, *Check-List Moll. Tas.*, p. 92, No. 898.
 1923. Id., May, *Ill. Index Tas. Shells*, pl. 42, fig. 8.

Size of average specimen.—Maj. diam., 17; min., 14; alt., 9 mm.

Localities.—Gippsland (J. A. Kershaw); Lakes Entrance (T. Worcester).

Obs.—A glossy species, hitherto unrecorded for Victoria. It approaches *Rhytida ruga*, Cox, but may be distinguished by its fewer and stronger ribs. The smooth character beneath is evident in both species. Comparison with specimens from near Launceston, Tasmania, the type locality, reveals an absolute identity.

RHYTIDA RUGA, Cox.

1871. *Helix ruga*, Cox, in Legrand Coll. *Mon. Tas. Land Shells*, sp. 24, pl. i, fig. 5.
 1879. Id., Petterd, *Mon. Tas. Land Shells*, p. 7.
 1882. *Helix exoptata*, Tate, *T.R.S.S.A.*, iv, p. 75.
 1887. *Helix (Videna) ruga*, Cox. Tryon, *Man. Conch.*, iii, p. 264, pl. 37, figs. 93-95.
 1905. *Rhytida (Eurhytida) ruga*, Cox. Moellendorff and Kobelt, *Conch. Cab. (Agnatha)*, p. 29, pl. 5, figs. 10-12.
 1909. *Rhytida ruga*, Cox. Petterd and Hedley, *Rec. Aust. Mus.*, vii, p. 286.
 1912. Id., Cox and Hedley, *Mem. Nat. Mus., Melb.*, No. 4, p. 7.
 1921. Id., May, *Check-List Moll. Tas.*, p. 92, No. 900.
 1923. Id., May, *Ill. Index Tas. Shells*, pl. 42, fig. 10.
 1929. Id., Gabriel, *Vic. Nat.*, xlvii (6), p. 131.

Size of Type.—Maj. diam., 9; min., 8; alt., 3 mm.

Localities.—Dandenong Ranges (Petterd and self); Rubicon and Daylesford (F. L. Billingham); Mallacoota (C. L. Barrett); Ararat and Timboon (H. W. Davey); Cann River (J. Clark); Lorne (self).

Obs.—One of our commoner forms, being generally distributed throughout the State. Comparison may be made with *Rhytida lampra*, Reeve, and *R. lamproides*, Cox. From the former, it is immediately separable by its finer sculpture, and from the latter by the absence of a bluntly angular periphery, which is so characteristic of that species. Consistency of contour is not apparent,

as the Cann River examples are a trifle higher in the spire. Professor Tate regarded the Victorian shells obtained at Dandenong, Sale, Cape Otway and Fernshaw as specifically distinct, and provided the name *Helix exoptata* without stating the points of difference. The species varies somewhat, but specimens may easily be matched with the island form, and the writer agrees with Cox and Hedley in placing the name into synonymy. The same authors remark: "The size principally distinguished *R. ruga* from its northern relations, and it may prove a dwarf of a widespread species which, in different parts of Australia, has received different names."

Usually found under stones and fallen timber.

RHYTIDA LAMPROIDES, COX.

- 1867. *Helix lamproides*, Cox, P.Z.S., Lond., p. 722.
- 1868. Id., Mon. Aust. Land Shells, p. 28, pl. 10, fig. 13.
- 1871. Id., (*Patula*), Cox, in Legrand Coll. Mon., sp. 7.
- 1879. Id., Petterd, Mon. Tas. Land Shells, p. 3.
- 1885. *Rhytida lamproides*, Cox, Tryon, Man. Conch., i, p. 124, pl. 23, fig. 51.
- 1905. *Rhytida* (*Eurhytida*) *lamproides*, Cox, Moellendorff and Kobelt, Conch. Cab. (*Agnatha*), p. 29, pl. 5, figs. 8, 9.
- 1909. *Rhytida lamproides*, Cox, Petterd and Hedley, Rec. Aust. Mus., vii, p. 286.
- 1921. Id., May, Check-List Moll. Tas., p. 92, No. 899.
- 1923. Id., May, Ill. Index Tas. Shells, pl. 42, fig. 9.

Size of Type.—Maj. diam., 14.47; min., 12.69; alt., 5.58 mm.

Locality.—Lillypilly Gully, National Park, Wilson's Promontory (Nat. Mus., collected by J. A. Kershaw; and E. S. Hanks).

Obs.—A species with a bluntly angular periphery, a feature which immediately contrasts it with the other Victorian members of the genus. The specimens were obtained under logs, and provide an additional entry for our fauna.

RHYTIDA GAWLERI, Brazier.

- 1873. *Helix* (*Zonites*) *gawleri*, Brazier, P.Z.S. Lond., p. 618.
- 1881. *Patula* (*Charopa*) *gawleri*, Braz. Pfr., Nomenc., p. 97.
- 1886. *Helix* (*Charopa*) *gawleri*, Braz. Tryon, Man. Conch., ii, p. 210.
- 1905. *Rhytida* (*Eurhytida*) *gawleri*, Braz. Moellendorff and Kobelt, Conch. Cab. (*Agnatha*), p. 37, pl. 7, figs. 12-14.

Size of Type.—Maj. diam., 16.92; min., 12.69; alt., 8.46 mm.

Localities.—Portland (W. H. Dillon); Dartmoor (C. L. Barrett); near mouth of Glenelg River (E. Ashby).

Obs.—A form coarsely wrinkled with oblique striae, which immediately separates it from its Victorian congeners. The author remarks: "This species appears to be quite common in a subfossil state in and around Adelaide."

Found nestling in the Bidgee-Widgee plant, *Acaena sanguisorba*, Vahl., by my late friend and keen naturalist, Mr. W. H. Dillon. Not previously recorded for Victoria.

Genus *Paryphanta*, Albers, 1850.*PARYPHANTA ATRAMENTARIA*, Shuttleworth.

1852. *Nanina atramentaria*, Shuttl., Mittheil. Naturf. Gesell. Bern., p. 194.
 1877. Id., Fischer, Notitiae Malacol., ii, p. 5, pl. i, fig. 2.
 1868. *Helix atramentaria*, Shuttl., Cox, Mon. Aust. Land Shells, p. 5, pl. 3, figs. 2a, 2b.
 1879. *Helicarion atramentaria*, Shuttl. T. Wds., P.L.S., N.S.W., iii, p. 124, pl. 12, figs. 2, 2a.
 1882. Id., Tate, T.R.S.S.A., iv, p. 75.
 1885. *Paryphanta atramentaria*, Shuttl. Tryon, Man. Conch., i, p. 127, pl. 26, figs. 5, 6.
 1912. Id., Cox and Hedley, Mem. Nat. Mus. Melb., No. 4, p. 8.
 1913. Id., Davies, P.R.S. Vic. (N.S.), xxv, p. 221, pl. 15, figs. 2, 5, pl. 17, fig. 9b (anatomy).

Size of Average Specimen.—Maj. diam., 31; min., 26; alt., 18 mm.

Localities.—Port Phillip (Shuttleworth); Mount Arnold and Bendigo (Cox); Fernshaw (Tate); Black Watch Range, Croajingolong (J. Searle); S. Gippsland (Rev. G. Cox); Olinda (self).

Obs.—The largest of the genus in Victoria, familiarly known as the "Black Snail." The anatomy of this species and *P. compacta*, Cox and Hedley, has been ably dealt with by O. B. Davies (loc. cit.). When contrasting the two species, the author stated: "The animal is much larger than *P. compacta*. The shell is flatter and of about the same colour, or, perhaps, a little lighter. The animal itself is the same dark grey colour, except at the edge of the mantle and the foot, where it is coloured a brilliant orange-red."

PARYPHANTA COMPACTA, Cox and Hedley.

1912. *Paryphanta compacta*, Cox and Hedley, Mem. Nat. Mus. Melb., No. 4, p. 8, pl. i, figs. 3, 4, 5.
 1913. Id., Davies, P.R.S. Vic. (N.S.), xxv, p. 221, pl. 15, figs. 1, 3, 4, pl. 16, fig. 6, pl. 17, figs. 7, 8, 9a, 10 (anatomy).

Size of Type.—Maj. diam., 24; min., 19; alt. 17 mm.

Localities.—Smithers Creek, Otway Ranges (A. D. Hardy) Type; Forrest (H. W. Davey); Mount Sabine; Erskine Falls (Kershaw); Splitters' Falls, Lorne (self).

Obs.—A handsome species readily distinguished from *P. atramentaria*, Shuttleworth, by its more globose form and more polished surface. It is apparently confined to the southern portion of the State, and no record is known to the writer east of the Otway Ranges.

Type in the Australian Museum, Sydney.

PARYPHANTA DYERI, Petterd.

1879. *Helix dyeri*, Pett., Mon. Tas., Land Shells, p. 40.
 1879. Id., Journ. Conch., ii, p. 210.

1909. *Paryphanta dyeri*, Pett. Petterd and Hedley, Rec. Aust. Mus., vii (4), p. 287, pl. 86, figs. 38-40.
 1921. Id., May, Check-List Moll. Tas., p. 92, No. 902.
 1923. Id., May, Ill. Index Tas. Shells, pl. 42, fig. 12.

Size of Type.—Maj. diam., 3.5; min., 2.5; alt., 1.5 mm.

Localities.—Tarraville, S. Gippsland (T. Worcester); Belgrave, Fern Tree Gully, Hall's Gap, Grampians (C. Oke); Olinda Falls, Splitters' Falls, Lorne (self); Warburton (F. E. Wilson).

Obs.—The smallest representative of the genus in Victoria. The author remarks: "Under the lens a very pretty, glossy species. Its nearest ally is *Helix nelsonensis*, Braz., from which it differs in being imperforate, and is more often rayed with chestnut markings. Like the great majority of land shells, it is a moist-loving species." This is an interesting addition to our fauna, having been detected in several localities throughout the State. Found nestling in moss (*Rhizogonium novae-hollandiae*, Brid.), and the Hepatic (*Blyttia spinosa*, Gotch).

Type from banks of Distillery Creek, near Launceston.

Family ENDODONTIDAE.

Genus *Charopa*, Albers, 1860.

CHAROPA TAMARENSIS, Petterd.

1879. *Helix tamarensis*, Petterd, Mon. Tas. Land Shells (April), p. 30.
 1879. *Helix rosacea*, Pett., Journ. of Conch., ii (July), p. 213 (*non Helix rosacea*, Muller, 1774).
 1882. Id., Tate, T.R.S.S.A., iv, p. 75.
 1893. *Charopa tamarensis*, Petterd, Billingham, Vic., Nat., x, p. 62.
 1894. *Endodonta tamarensis*, Pett. Pilsbry, Man. Conch., ix, p. 35.
 1894. *Flammulina tamarensis*, Pett. Pils. Man. Conch., ix, p. 338.
 1896. *Endodonta tamarensis*, Pett. Hedley, Rec. Aust. Mus., ii, p. 104.
 1903. Id., Hedley, P.L.S., N.S.W., xxvii, p. 605, pl. 31, figs. 18-20.
 1909. Id., Pett. and Hed., Rec. Aust. Mus., vii, p. 291.
 1912. Id., Cox and Hed., Mem. Nat. Mus. Melb., No. 4, p. 10.
 1921. Id., May, Check-List Tas. Moll., p. 94, No. 917.
 1923. Id., May, Ill. Index Tas. Shells, pl. 42, fig. 17.
 1929. *Charopa tamarensis*, Pett. Gabriel, Vic. Nat., xlvii (6), p. 132.

Size of Type.—Maj. diam., 6; min., 5; alt., 2 mm.

Localities.—Burrumbeet (Tate); Mount Franklin (Billingham); Meredith (J. H. Young); Fern Tree Gully (C. Oke); Geelong (H. W. Davey); Cann River (J. Clark); Longford; Mt. Martha; Croydon.

Obs.—A characteristic little species, readily recognised by its wide umbilicus and rays of rusty-brown colour. The type locality is rifle butts, near Launceston, Tasmania. In Victoria, it is widely distributed, and Hedley records a northern extension to Mt. Kosciusko, having been located at Wilson's Valley, at an altitude of 4500 feet. Found generally under stones and in moss.

CHAROPA ALBANENSIS, COX.

1867. *Helix albanensis*, Cox, P.Z.S. Lond., p. 723.
 1868. Id., Mon. Aust. Land Shells, p. 15, pl. 4, fig. 2.
 1871. *Helix macdonaldi*, Cox, in Legrand Coll. Mon., sp. 32, pl. 1, fig. 14.
 1871. *Helix kingstonensis*, Cox, loc. cit., sp. 40, pl. 2, fig. 5.
 1871. *Helix officieri* Cox, loc. cit., sp. 57.
 1879. *Helix stanleyensis*, Petterd, Mon. Tas., Land Shells, p. 32.
 1879. *Helix petterdiana*, Taylor, Journ. Conch., p. 287, pl. 1, fig. 3.
 1882. *Helix stanleyensis*, Pett. Tate, T.R.S.S.A., iv, p. 75.
 1886. *Charopa albanensis*, Cox, Tryon, Man. Conch., ii, p. 209, pl. 62, figs. 25, 26.
 1892. Id., Hedley, P.L.S. N.S.W. [2], vii, p. 163, pl. 2, figs. 5-8.
 1894. *Endodonta albanensis*, Cox. Pilsbry, Man. Conch., ix, p. 34.
 1895. Id., Hed., P. Mal. Soc. Lond., i, p. 260.
 1896. Id., Hed., Rec. Aust. Mus., ii, p. 104.
 1909. Id., Hed. and Pett., Rec. Aust. Mus., vii, p. 288.
 1912. Id., Cox and Hed., Mem. Nat. Mus. Melb., No. 4, p. 9.
 1921. Id., May, Check-List Tas. Moll., p. 93, No. 905.
 1923. Id., May, Ill. Index Tas. Shells, pl. 42, fig. 16.

Size of Type.—Maj. diam., 5.07; min., 4.57; alt., 2.53 mm.

Localities.—Fernshaw (Petterd); Wimmera (Aust. Mus.); Gippsland and Wilson's Prom. (Kershaw); Belgrave (C. Oke); Tarraville (T. Worcester); Warburton (F. E. Wilson); Lorne (self).

Obs.—An umbilicated species with radiating reddish-brown bands. The Victorian and Tasmanian representatives show a slight difference, the ribs being a little more numerous. This feature, however, is not constant, as intermediate specimens occasionally appear.

Type from King George's Sound.

CHAROPA FUNEREA, COX.

1868. *Helix funerea*, Cox, Mon. Aust. Land Shells, p. 16, pl. 3, fig. 1.
 1886. *Charopa funerea*, Cox. Tryon, Man. Conch., ii, p. 209, pl. 62, figs. 23, 24.
 1894. *Endodonta funerea*, Cox. Pilsbry, Man. Conch., ix, p. 34.
 1896. Id., Hedley, Rec. Aust. Mus., ii, p. 104.
 1912. Id., Cox and Hedley, Mem. Nat. Mus. Melb., No. 4, p. 9.
 1912. *Endodonta murrayana*, Pfr. var. *submurrayana*, Cox and Hedley, loc. cit., p. 10, pl. 1, figs. 6-8.

Size of Type.—Maj. diam., 6.34; min., 5.33; alt., 2.53 mm.

Localities.—Frankston (Aust. Mus.); Jan Juc, Mulgrave, Black's Spur (Nat. Mus. Melb.); Burrumbeet (Tate); Bairnsdale (Kershaw); Mount Shadwell (Whan); Meredith (J. H. Young); Mt. Franklin (Billinghurst); Nowa Nowa, Whitfield. Hamilton (self).

Obs.—A brown, closely-ribbed species, widely distributed throughout the State. The type locality is Mudgee, N.S.W., and Hedley (loc. cit.) records it from S. Queensland. The author remarks: "Apparently little subject to variation in colour, very beautifully representing *H. inusta*, but more coarsely sculptured,

and having a large umbilicus." Petterd and Hedley regard *E. ricei*, Braz., from Tasmania, as being similar, but "a narrower umbilicus, greater height in proportion to diameter and finer sculpture," separate it. Having examined the types of *E. funerea*, Cox, and *E. murrayana*, Pfr., var. *submurrayana*, Cox and Hedley, the writer is convinced that one form only is represented, and the latter must sink as a synonym. *E. murrayana*, Pfr., is quite a distinct species, being flatter, with wider umbilicus, and more distant radial lamellae. Found under stones and decayed timber.

CHAROPA RETIPORA, Cox.

- 1867. *Helix retipora*, Cox, P.Z.S. Lond., p. 39.
- 1868. *Helix retepora*, Cox, Mon. Aust. Land Shells, p. 21, pl. 7, figs. 8, 8a.
- 1887. *Helix retipora*, Cox. Tryon, Man. Conch., iii, p. 34, pl. 7, figs. 95, 96.
- 1894. *Endodonta retepora*, Cox, Pilsbry, Man. Conch., ix, p. 34.

Size of Type.—Maj. diam., 5.33; min., 4.31; alt., 2.79 mm.

Locality.—Expedition Pass, Chewton (F. L. Billinghamurst).

Obs.—A dull, reddish-brown, perforated shell, with some of the ribs at somewhat regular intervals much more projecting than others, the interstices crossed by minute and close-raised lines.

CHAROPA RETIPORA, Cox, var. MELBOURNENSIS, Cox.

- 1868. *Helix melbournensis*, Cox, Mon. Aust. Land Shells, p. 22, pl. 12, fig. 10.
- 1882. Id., Tate, T.R.S.S.A., iv, p. 75.
- 1887. Id., Tryon, Man. Conch., iii, p. 35, pl. 7, figs. 97-99.
- 1893. *Helix retipora*, Cox. Billinghamurst, Vic. Nat., x, p. 62.
- 1894. *Endodonta melbournensis*, Cox. Pilsbry, Man. Conch., ix, p. 34.
- 1903. Id., Hedley, P.L.S. N.S.W., xxvii (1902), p. 604, pl. 31, figs. 16, 17.
- 1912. *Endodonta retipora*, Cox, var. *melbournensis*, Cox. Cox and Hedley, Mem. Nat. Mus. Melb., No. 4, p. 10.

Size of Type.—Maj. diam., 5.07; min., 4.31; alt., 3.55 mm.

Localities.—Melbourne (Masters); Fernshaw (Petterd); Castlemaine and Harcourt (Billinghamurst); Gippsland and Wimmera (Aust. Mus.); Mount Macedon; Dandenong Range, Western Port (Kershaw); Meredith (J. H. Young); Anakie Ranges (C. Oke); Whitfield (self); You Yangs (C. L. Barrett); Berwick and Jan Juc (Nat. Mus. Melb.).

Obs.—The author describes the shell as being finely and regularly striated, but, as Cox and Hedley (loc. cit.) remark, the difference is not constant enough for specific distinction. Pilsbry (loc. cit.) regards this form as a synonym of *E. sericatula*, Pfr., a decision which is not generally accepted. Frequently located under stones.

CHAROPA SERICATULA, Pfeiffer.

1850. *Helix sericatulæ*, Pfeiffer, P.Z.S. Lond. for 1849, p. 127.
 1852. Id., Reeve, Conch., Icon., vii, pl. 132, fig. 812.
 1868. Id., Cox, Mon. Aust. Land Shells, p. 12, pl. 12, figs. 6, 6a.
 1871. *Helix* (*Charopa*) *limula*, Cox, in Legrand Coll. Mon., sp. 72.
 1886. *Charopa sericatulæ*, Pfr. Tryon, Man. Conch., ii, p. 208, pl. 62, figs. 17, 18.
 1894. *Endodonta sericatulæ*, Pfr. Pilsbry, Man. Conch., ix., p. 34.
 1909. Id., Petterd and Hedley, Rec. Aust. Mus., vii, p. 291.
 1921. Id., May, Check-List Moll. Tas., p. 94, No. 915.
 1923. Id., May, Ill. Index Tas. Shells, pl. 43, fig. 2.

Size of Type.—Maj. diam., 4·5; min., 4; alt., 2·3 mm.

Locality.—East Gippsland (Nat. Mus. Melb.), collected by W. Kershaw.

Obs.—“A shell easily recognised, although it varies much in markings, and is sometimes without any, and entirely of a light brown. Usually the ribs are black at intervals, or wholly, giving the shell a streaked appearance” (Dr. Cox). Pilsbry (loc. cit.) regards *E. melbournensis* as a synonym, a decision with which the writer cannot agree. This is an addition to our fauna. The type locality is Port Jackson, and it appears in Tasmania.

CHAROPA ELENESCENS, Cox and Hedley.

1912. *Flammulina elenescens*, Cox and Hedley, Mem. Nat. Mus. Melb., No. 4, p. 12, pl. 3, figs. 16-18.

Size of Type.—Maj. diam., 6·7; min., 5·4; alt., 2·9 mm.

Localities.—Merri Creek (Tenison Woods); Preston (C. L. Barrett); Geelong (H. W. Davey); Sunshine (J. E. Dixon); Broadmeadows.

Obs.—A rather flat species with a broad umbilicus. The authors remark: “In general appearance like *F. diemenensis* and *F. marchi-anae*, between which it is intermediate in size. The break in sculpture of *F. elenescens* readily distinguishes it.” Though not typical, this species appears to be more happily placed in *Charopa*.

Type in the Australian Museum, Sydney.

CHAROPA DIEMENENSIS, Cox.

1868. *Helix diemenensis*, Cox, P.Z.S. Lond. for 1867, p. 723.
 1868. *Helix wellingtonensis*, Cox, P.Z.S. Lond. for 1867, p. 723.
 1868. *Helix diemenensis*, Cox, Mon. Aust. Land Shells, p. 20, pl. 7, figs. 6, 6a.
 1868. *Helix wellingtonensis*, Cox, Mon. Aust. Land Shells, p. 29, pl. 7, figs. 5, 5a.
 1871. *Helix daveyensis*, Cox. Cox, in Legrand Coll. Mon., sp. 35, pl. 2, fig. 4.
 1871. *Helix atkinsoni*, Cox, loc. cit., sp. 62, pl. 2, fig. 12.
 1871. *Helix thompsoni*, Cox, loc. cit., sp. 73.
 1871. *Helix caniffæ*, Cox, loc. cit., sp. 74.
 1874. *Helix midsonti*, Brazier. Braz., in Legrand Coll. Mon. Addenda.
 1880. *Helix diemenensis*, Cox. Johnston, P.R.S. Tas. for 1879, p. 49.
 1887. Id., Tryon, Man. Conch., iii, p. 24, pl. 3, figs. 16-18.

1887. *Helix daveyensis*, Cox. Tryon, Man. Conch, iii, p. 265, pl. 37, figs. 87, 88.
 1887. *Helix atkinsoni*, Cox. Tryon, Man. Conch., iii, p. 266, pl. 37, figs. 89, 90.
 1894. *Endodonta diemenensis*, Cox. Pilsbry, Man. Conch., ix, p. 34.
 1894. *Flammulina diemenensis*, Cox. Suter, Ann. Mag. Nat. Hist. [6], xiii, p. 64.
 1909. Id., Petterd and Hedley, Rec. Aust. Mus., vii, No. 4, p. 299.
 1921. Id., May, Check-List Moll. Tas., p. 96, No. 935.
 1923. Id., May, Ill. Index Tas. Shells, pl. 43, fig. 18.

Size of Type.—Maj. diam., 9.39; min., 8.37; alt., 3.55 mm.

Locality.—Mount William (Nat. Mus. Melb.), collected by J. Clark.

Obs.—A shell with numerous riblets, and many radiate pale-red bands. It is common in Tasmania, and on the islands in Bass Straits. This addition to our fauna is based on a specimen obtained by Mr. Clark.

Found under decayed timber.

CHAROPA ERSKINENSIS, sp. nov. (Pl. II, Figs. 1, 2).

Shell small, cream-colour, glossy, discoidal, distinctly umbilicated, the umbilicus being deep and about one-fourth of the shell's diameter in breadth, exposing all preceding whorls. Whorls, including protoconch, about four and one half, well rounded, parted by deeply impressed sutures, the last slightly descending. Sculpture: the whorls are crossed by fine, regularly-spaced radial riblets to the number of about 154 on the ultimate. Further ornamentation may be seen in the interstices, which are cancellated by microscopic radials and spiral hair-lines. Aperture lunate, lip simple, callus on the previous whorl distinct, concealing several of the riblets.

Size of Type.—Maj. diam., 2.5; min., 2; alt., 1.0 mm.

Localities.—Near "Sanctuary," Erskine River, Lorne (Type, self); Splitter's Falls, Lorne (self). Found under charred logs.

Obs.—A delicate little species, quite distinct from any Victorian form. Its nearest ally is perhaps the Tasmanian *F. roblini*, Pett. On comparative examination with authentic specimens in the Hobart Museum, distinctive characters were readily discernible. The novelty is flatter, the umbilicus a trifle larger, and the absence of a spirally-striate apex immediately separates it.

CHAROPA GATLIFFI, sp. nov. (Pl. II, Figs. 3, 4).

Shell small, thin, shining, subdiscoidal, finely ribbed, broadly umbilicated, light-brown colour with irregular darker-brown zig-zag bands crossing the whorls, the bands being plainly visible in the umbilicus, which is wide and almost one-third of the shell's diameter. The umbilicus is deep, exposing all the volutions. Whorls about four and one-half, regularly increasing, well rounded, and parted by deeply impressed sutures. The whorls are

ornamented by delicate, closely-set, evenly-spaced radial riblets, traceable to the extreme apex, and which penetrate the umbilicus, numbering about 210 on the ultimate whorl. Between the riblets the surface is microscopically reticulated by fine growth and spiral striae, the latter being slightly stronger in the umbilicus. Aperture rotundly-lunate, lip thin, callus on the preceding whorl resolving itself into a thin, whitish, polished layer, which covers several of the riblets.

Size of Type.—Maj. diam., 3·3; min., 2·8; alt., 1·7 mm.

Localities.—Type near Splitters' Falls, Lorne (self); also at most of the Falls in this district (self). Found under stones.

Obs.—Though small, a well-marked, elegant form, with very little affinity to any Victorian species. The characteristic zig-zag banding will serve as a useful recognition mark. *E. tamarensis*, Pett., which has a faint resemblance, is, however, flatter, possesses a coarser sculpture and a wider umbilicus. I have much pleasure in associating this ornate little species with the name of my friend and collaborator, Mr. J. H. Gatliff.

CHAROPA TARRAVILLENSIS, sp. nov. (Pl. II, Figs. 5, 6).

Shell small, fragile, light-brown, shining, umbilicated, subdiscoid, apex fairly conspicuous, finely ribbed. Whorls about four and one-half, including protoconch, well-rounded, the ultimate gradually descending to about one quarter the depth of the previous whorl. Sutures deeply impressed. Sculpture: protoconch finely, radially striate, the succeeding whorls ornamented with closely-set sub-equidistant radial ribs which are clearly visible in the umbilicus, and number about 84 on the last whorl. Interstitial surface with fine riblets, decussate by microscopic spiral striae. Umbilicus wide and deep, about one quarter of the shell's diameter in width, exposing all previous volutions. Aperture roundly lunate. Peristome acute, regularly curved. Several ribs in front of aperture covered by a shining whitish callus glaze.

Size of Type.—Maj. diam., 2·6; min., 2·3; alt., 1·2 mm.

Locality.—Tarraville (T. Worcester).

Obs.—The Tasmanian *H. legrandi*, Cox, somewhat resembles this species, but on comparison with authentic specimens in the Hobart Museum, distinctive features are at once discernible, the novelty not being so flat and possessing a narrower umbilicus.

CHAROPA SCINDOCATARACTA, sp. nov. (Pl. II, Figs. 9, 10).

Shell, minute, planorbiform, spire slightly sunken, shining, cream-colour, with narrow splashes and streaks of lighter coloration crossing the whorls at irregular intervals, discoidal, unusually thin and fragile, umbilicated, whole surface finely, radiately ribbed. Including protoconch whorls about four and one-half, gradually increasing in width, rounded, and parted by well-impressed sutures, last whorl not descending. Sculpture consisting of numerous, equidistant, microscopic radial riblets, about 205

on the body-whorl, visible to the extreme apex, and which may be traced into the well-defined umbilicus. The whorls are further ornamented by extremely fine, concentric striae. Aperture lunate. Peristome simple, thin, sharp, regularly rounded. Glazed callosity on the preceding whorl well-marked, covering many of the riblets. Umbilicus wide, about one-fifth of the shell's diameter, exposing all previous whorls.

Size of Type.—Maj. diam., 1.5; min., 1.3; alt., 0.7 mm.

Localities.—Type near Splitters' Falls, Lorne (self); also at most of the Falls in this district (self). Found under stones.

Obs.—Though minute, the species may be easily recognised by its discoidal shape and light splashes of colour, which are constant features, and separate it from any Victorian form. Its nearest ally is, perhaps, the Tasmanian *E. antialba*, Bedd., from which it may be distinguished by its smaller umbilicus, less sunken spire, and lighter coloration.

CHAROPA BAIRNSDALENSIS, sp. nov. (Pl. II, Figs. 11, 12).

Shell minute, fragile, light horn-colour, broadly umbilicated, sub-discoidal, distinctly ribbed. Apex fairly prominent. Whorls about four and one half, including protoconch, rather convex, parted by well impressed sutures, the last slightly descending. Sculpture consisting of rather sharp, radial ribs, traceable almost to apex, fairly regularly spaced, which may be seen entering the umbilicus; the ribs being disposed to the number of 28 on the ultimate whorl. The whorls are further ornamented by fine intermediate riblets. Under high power faint traces of spiral scratches are discernible. Umbilicus in width about five-twelfths of the shell's diameter, very open, exposing all previous whorls. Aperture rotundly lunar, in front of which two or three ribs are concealed in callus (outer lip fractured).

Size of Type.—Maj. diam., 2.0; min., 1.8; alt., 0.9 mm.

Locality.—Bairnsdale (T. Worcester).

Obs.—A species with few ribs. Its nearest ally is, perhaps, *H. cochlidium*, Cox. Compared with authentic specimens in the Aust. Mus. from the type locality, Clarence River, N.S.W., the novelty is flatter, and possesses a larger umbilicus.

Family LAOMIDAE.

Genus *Laoma*, Gray, 1849.

LAOMA MORTI, Cox.

1864. *Helix morti*, Cox, Ann. Mag. Nat. Hist. [3], xiv, p. 182.

1864. *Helix paradoxa*, Cox, Cat. Aust. Land Shells, p. 21.

1864. *Helix morti*, Cox, Cat. Aust. Land Shells, p. 22.

1868. Id., Mon. Aust. Land Shells, p. 21, pl. 11, fig. 13.

1868. *Helix hobarti*, Cox, Mon. Aust. Land Shells, p. 22 (not pl. 12, fig. 11, as quoted).

1868. *Helix similis*, Cox, Mon. Aust. Land Shells, p. 23, pl. 12, fig. 12 (*non* *H. similis*, C. B. Adams).

1870. *Helix stellata*, Brazier, P.Z.S. Lond., p. 662.
 1871. *Helix derelicta*, Cox, in Legrand Coll. Mon., sp. 11.
 1878. *Helix arenicola*, Tate, P.L.S. N.S.W., ii, p. 291.
 1882. *Helix morti*, Cox. Tate, T.R.S.S.A., iv, p. 75.
 1882. *Helix hobarti*, Cox. Tate, T.R.S.S.A., iv, p. 75.
 1887. *Helix morti*, Cox. Tryon, Man. Conch., iii, p. 34, pl. 7, figs. 87, 88.
 1894. *Charopa retinodes*, Tate. T.R.S.S.A., xviii, p. 192.
 1894. *Endodonta paradoxa*, Cox. Pilsbry, Man. Conch., ix, p. 34.
 1894. *Laoma hobarti*, Cox. Pils. Man. Conch., ix, p. 338.
 1895. *Patula morti*, Cox. Smith, P. Mal. Soc. Lond., i, p. 87 (read 1894).
 1896. *Flammulina retinodes*, Tate, Horn, Exp. Zool., ii, p. 187, pl. 17, figs. 4a, b, c.
 1902. *Helix discors*, Petterd, P.R.S. Tas. for 1900, p. 2.
 1909. *Laoma morti*, Cox. Petterd and Hedley, Rec. Aust. Mus., vii, No. 4, p. 294.
 1912. Id., Cox and Hedley, Mem. Nat. Mus. Melb., No. 4, p. 11.
 1921. *Laoma morti*, Cox. May, Check-List Moll. Tas., p. 95, No. 926.
 1923. Id., May, Ill. Index Tas. Shells, pl. 43, fig. 12.

Size of Type.—Maj. diam., 2.03; min., 1.77; alt., 1.01 mm.

Localities.—Mount Eliza (Pritchard and self); Jan Juc (Kershaw); Sea Lake (J. C. Goudie); Castlemaine (F. L. Billinghurst); Mornington (Rev. G. Cox); Bannerton (A. C. Nilson); Belgrave (C. Oke); University Grounds (Nat. Mus.); Wangaratta and Edi (self).

Obs.—A small species, presenting features which are subject to considerable variation, hence the heavy synonymy. It is widely distributed, being recorded from New South Wales, Victoria, South Australia, Western Australia and Tasmania.

Found under stones, dry timber, and fallen leaves.

LAOMA MUCOIDES, Tenison Woods.

1879. *Helix mucoides*, Tenison Woods, P.L.S. N.S.W., iii, p. 125, pl. 12, figs. 5, 5a.
 1882. Id., Tate, T.R.S.S.A., iv, p. 75.
 1887. *Helix mucoides*, Stephens (in error for Ten. Wds.). Tryon, Man. Conch., iii, p. 44, pl. 5, figs. 75, 76.
 1894. *Endodonta mucoides*, T. Wds. Pilsbry, Man. Conch., ix, p. 34.
 1912. *Laoma mucoides*, T. Wds. Cox and Hedley, Mem. Nat. Mus. Melb., No. 4, p. 11, pl. 2, figs. 9-12.

Size of Type.—Maj. diam., 3; min., 2.5; alt., 1.5 mm.

Localities.—Melbourne (Type); Meredith (J. H. Young); Gong Gong Reservoir (C. Oke); Trentham Falls (J. K. Gabriel); Splitters' Falls, Lorne (self).

Obs.—In form and sculpture a close ally of *L. morti*, Cox. Both species possess radial lamellae, which are better developed in *L. mucoides*. The last whorl is obtusely carinated, a feature absent in *L. morti*.

Type in Australian Museum, Sydney.

LAOMA PENOLENSIS, COX.

1867. *Helix penolensis*, Cox, P.Z.S. Lond., p. 724.
 1868. Id., Mon., Aust. Land Shells, p. 8, pl. 11, fig. 12.
 1878. *Helix pictilis*, Tate, P.L.S. N.S.W., ii, p. 290.
 1886. *Helix penolensis*, Cox. Tryon, Man. Conch., ii, p. 179, pl. 54, figs. 93, 94.
 1894. *Laoma pictilis*, Tate. Pilsbry, Man. Conch., ix, p. 10.
 1894. Id., Suter, Ann. Mag. Nat. Hist. [6], xiii, p. 64.
 1909. Id., Petterd and Hedley, Rec. Aust. Mus., vii (4), p. 294, pl. 86, figs. 35-37.
 1912. *Laoma penolensis*, Cox. Cox and Hedley. Mem. Nat. Mus. Melb., No. 4, p. 11.
 1921. Id., May, Check-List Moll. Tas., p. 95, No. 927.
 1923. Id., May, Ill. Index Tas. Shells, pl. 43, fig. 5.

Size of Type.—Maj, diam., 3·8; min., 3·3; alt., 2·03 mm.

Localities.—Port Fairy (Rev. W. T. Whan); near Melbourne and Oberon Bay (J. A. Kershaw); Lorne (Dr. G. B. Pritchard); Frankston and Grampians (C. Oke); Portland; Meredith; San Remo; Bairnsdale; Tarraville.

Obs.—A rather dull, horny, broadly semi-conical species, widely distributed throughout the State. Tate distinguished *H. pictilis* from *H. penolensis* by its "coarser ribbing, its coloration, and the presence of transverse striae." As Cox and Hedley (loc. cit.) remark, the first and second characters are variable, and examination of the type of *H. penolensis* in the Cox collection reveals the presence of microscopic spiral striae. The same authors note that Cape Northumberland, the type locality of *H. pictilis*, is but a short distance from Penola, where the type of *H. penolensis* was found. That one species only is represented it is obvious, and *H. pictilis* must sink as a synonym.

LAOMA MINIMA, COX.

1868. *Helix minima*, Cox, Mon. Aust. Land Shells, p. 10, pl. 12, fig. 8.
 1877. *Helix collisi*, Brazier, P.R.S., Tas. for 1876, p. 168.
 1879. *Helix henryana*, Petterd, Mon. Tas. Land Shells, p. 21.
 1879. *Helix furneauxensis*, Petterd, Mon. Tas., Land Shells, p. 21.
 1879. Id., Petterd, Journ. Conch., ii, p. 215.
 1894. *Laoma henryana*, Petterd. Suter, Ann. Mag. Nat. Hist. [6], xiii, p. 64.
 1894. *Endodonta furneauxensis*, Petterd. Pilsbry, Man. Conch., ix, p. 34.
 1894. *Laoma furneauxensis*, Pett. Pils. Man. Conch., ix, p. 338.
 1894. Id., Suter, Ann. Mag. Nat. Hist. [6], xiii, p. 64.
 1909. *Laoma minima*, Cox, Petterd and Hedley, Rec. Aust. Mus., vii, No. 4, p. 295.
 1921. Id., May, Check-List Moll. Tas., p. 94, No. 925.
 1923. Id., May, Ill. Index Tas. Shells, pl. 43, fig. 10.

Size of Type.—Maj. diam., 1·77; min., 1·52; alt., 0·76 mm.

Localities.—Bairnsdale and Tarraville (T. Worcester); Car-rum (C. Oke).

Obs.—A small, shining, broadly umbilicated species, with nothing approaching it in Victoria. This is an addition to our fauna. Found under stones and fallen leaves. Type in Australian Museum, Sydney.

LAOMA HALLI, Cox.

1871. *Helix halli*, Cox, in Legrand Coll. Mon., sp. 34, pl. 2, fig. 9.
 1879. Id., Petterd, Mon. Tas. Land Shells, p. 22.
 1887. *Helix* (*Rhyssota*) *halli*, Cox. Tryon, Man. Conch., iii, p. 264, pl. 37, figs. 54, 55.
 1894. *Laoma halli*, Cox. Suter, Ann. Mag. Nat. Hist. [6], xiii, p. 64.
 1894. *Endodonta halli*, Cox. Pilsbry, Man. Conch., ix, p. 34.
 1894. *Laoma halli*, Cox. Pils., Man. Conch., ix, p. 338.
 1909. Id., Petterd and Hedley, Rec. Aust. Mus., vii, p. 295.
 1921. Id., May, Check-List Moll. Tas., p. 94, No. 922.
 1923. Id., May, Ill. Index Tas. Shells, pl. 43, fig. 11.

Size of Type.—Maj. diam., 1.52; min., 1.26; alt., 1.01 mm.

Localities.—Castlemaine (F. L. Billingham); Frankston and Tarraville (T. Worcester); Fern Tree Gully, Mt. Donna Buang (C. Oke); Trentham Falls (J. K. Gabriel); Grampians, Lorne (self).

Obs.—A minute form, found under decaying wood, and in moss. Narrowly umbilicated and finely striated. It is rather remarkable the species has escaped notice for so long, as it appears to be widely distributed. Consistency in shape is not apparent, as considerable variation is seen, more particularly in regard to height.

LAOMA TURBINULOIDEA, sp. nov. (Pl. II, Fig. 7).

Shell small, umbilicated, shining, chocolate-brown colour, thin, turbinately globose; spire obtusely conical; apex well rounded. Whorls, including protoconch, about four and one half, regularly increasing, and conspicuously convex. Sutures deeply impressed. In the earlier stages, the whorls are ornamented by close, even, thread-like radials, which, as growth continues, are rounder, wider apart and irregularly spaced. This sculpture is visible within the umbilicus. Aperture, slightly oblique, lunate; peristome thin, regular, columellar margin partially concealing the umbilicus. The umbilicus is about one-fourth of the shell's diameter.

Size of Type.—Maj. diam., 2.2; min., 2.2; alt., 2.0 mm.

Locality.—Bairnsdale (T. Worcester).

Obs.—From its Victorian congeners it is immediately distinguished by the well-rounded whorls and characteristic chocolate-brown colour. A suggestion has been made that this species represents a new genus, but it is preferred to allow its inclusion here until more is known of these puzzling forms.

LAOMA SINISTRA, sp. nov. (Pl. II, Fig. 8).

Shell small, fragile, horn-colour, semi-transparent, sinistral, narrowly umbilicated; spire obtusely-conical; apex fairly prom-

inent and finely spirally liriate. Whorls, including protoconch, about six and one-half, convex. Sutures well impressed. Sculpture of post-nuclear whorls consisting of somewhat inequidistant, microscopic radial riblets which vary in strength, are obliquely situated, and may be seen entering the umbilicus. Interstices with fairly numerous growth-striae and microscopic spiral lines. Aperture rotundly lunate. Peristome simple, sharp and thin.

Size of Type.—Maj. diam., 1.0; min., 1.0; alt., 1.2 mm.

Localities.—Tarraville (Type, T. Worcester); Fern Tree Gully (C. Oke).

Obs.—This novelty provides an interesting addition to the infrequent sinistral forms. It approaches the Tasmanian *H. weldii*, T. Wds. An authentic specimen of this species from the type locality, Circular Head, received from the late Mr. W. L. May, is of much broader proportions. The specimens collected at Fern Tree Gully were found nestling in moss.

Genus *Allodiscus*, Pilsbry, 1892.

ALLODISCUS OTWAYENSIS, Petterd.

1879. *Helix otwayensis*, Petterd, Mon. Tas. Land Shells (April), p. 39.

1879. Id., Journ. of Conch., ii (December), p. 356.

1880. Id., Johnston, P.R.S., Tas. for 1879, p. 24.

1882. Id., Tate, T.R.S.S.A., iv, p. 75.

1886. *Charopa otwayensis*, Petterd. Tryon, Man. Conch., ii, p. 210.

1894. *Endodonta otwayensis*, Pett. Pilsbry, Man. Conch., ix, p. 34.

1903. Id., Hedley, P.L.S. N.S.W., xxvii, p. 605, pl. 29, figs. 10-12.

1909. *Flammulina otwayensis*, Pett. Pett. and Hedley, Rec. Aust. Mus., vii (4), p. 300, pl. 85, figs. 23-25.

1912. Id., Cox and Hedley, Mem. Nat. Mus. Melb., No. 4, p. 13.

1921. Id., May, Check-List Moll. Tas., p. 96, No. 941.

1923. Id., May, Ill. Index Tas. Shells, pl. 43, fig. 21.

Size of Type.—Maj. diam., 2; min., 1.5; alt., 1 mm.

Localities.—Cape Otway (Petterd); Fernshaw (Kershaw); Fern Tree Gully and Gong Gong Reservoir, Ballarat (C. Oke); Taggerty (Nat. Mus. Melb.); Mt. Dandenong (self), Tarraville (T. Worcester).

Obs.—An ornate little species, imperforate and with the interstices minutely decussate. The type locality is Cape Otway scrubs. Cox and Hedley record it from Tasmania. The dimensions of the type are exceeded in a specimen from Fern Tree Gully, which measures 3 mm.

ALLODISCUS SUBDEPRESSUS, Brazier.

1871. *Helix subdepressa*, Brazier, P.Z.S. Lond., p. 641.

1879. *Helix dandenongensis*, Petterd, Journ. of Conch., ii, p. 355.

1882. Id., Tate, T.R.S.S.A., iv, p. 75.

1894. *Endodonta subdepressa*, Braz. Pilsbry, Man. Conch., ix, p. 34.

1903. Id., Hedley, P.L.S. N.S.W., xxvii, p. 605, pl. 31, figs. 13-15.

1912. *Flammulina subdepressa*, Braz. Cox and Hedley, Mem. Nat. Mus. Melb., No. 4, p. 13.

Size of Type.—Maj. diam., 3·17; min., 2·11; alt., 1·05; diameter of umbilicus, 1·58 mm.

Localities.—Snowy River and Fernshaw (Kershaw); Dandenong Range (Petterd and self); Oakleigh (French); Gembrook (Coghill); Emerald District (Jarvis); Yarragon (Nat. Mus. Melb.); S. Gippsland (Rev. G. Cox); Korumburra (F. L. Billinghamurst); Lorne (self).

Obs.—A white shell, with an umbilicus equalling more than half the diameter. It is of gregarious habit, being commonly located in large numbers under decayed timber and among moss.

ALLODISCUS MERACUS, Cox and Hedley.

1912. *Flammulina meraca*, Cox and Hedley, Mem. Nat. Mus. Melb., No. 4, p. 13, pl. 3, figs. 19-21.

Size of Type.—Maj. diam., 4; min., 3; alt., 2 mm.

Localities.—Dandenong Ranges (Kershaw); Fernshaw (Petterd); Olinda and Lorne (self); Belgrave, Evelyn.

Obs.—A pure white species, found mostly under fallen logs and frequently associating with *H. subdepressa*, Braz. The animal is of a very dark colour, rendering it more difficult to detect than the species named. The authors remark: 'It is nearest related to *F. nivea*, Hedley, from Kosciusko, which differs in the microscopic details of the sculpture, is more closely coiled, and has a sunken instead of an elevated spire.' Two specimens collected by the writer at Paradise Falls, near Whitfield, show a slight increase in the size of the umbilicus, but are otherwise identical. The Type is in the National Museum, Melbourne.

ALLODISCUS CANNFLUVIATILUS, Gabriel.

1929. *Allodiscus cannfluviatilus*, Gabriel, Vic. Nat., xlvii (6), p. 133, figs. 1, 2, and text fig.

Size of Type.—Maj. diam., 2·8; min., 2·4; alt., 1·7 mm.

Locality.—Cann River (Nat. Mus. Melb.), collected by J. Clark.

Obs.—A distinctive little form. The spiral lirae bordering the umbilicus provide a helpful and striking diagnostic character. The species somewhat resembles *H. otwayensis*, Petterd, from which it may be distinguished by its fewer ribs and the presence of an umbilicus.

Genus *Thalassohelix*, Pilsbry, 1892.

THALASSOHELIX FORDEI, Brazier, var. *m'coyi*, Petterd.

1879. *Helix fordei*, var. *m'coyi*, Petterd, Mon. Tas. Land Shells, p. 14.

1879. *Helix fernshawensis*, Petterd, Journ. of Conch., ii, p. 355.

1879. Id., Mon. Tas. Land Shells, p. 15.

1882. *Helix m'coyi*, Pett. Tate, T.R.S.S.A., iv, p. 75.

1882. *Helix fernshawensis*, Pett. Tate, T.R.S.S.A., iv, p. 75.

1886. *Nanina fernshawensis*, Pett. Tryon, Man. Conch., ii, p. 124.
 1887. *Helix fernshawensis*, Pett. Tryon, Man. Conch. iii. p. 36.
 1912. *Flammulina fordei*, Braz., var. *m'coyi*, Pett. Cox and Hedley,
 Mem. Nat. Mus. Melb., No. 4, p. 12, pl. 2, figs. 13-15.

Size of Type.—Maj. diam., 7·61; min., 5·58; alt., 4·06 mm.

Localities.—Dandenong Range (Petterd); Fernshaw (Tate); Don River (Nat. Mus. Melb.); Upper Yarra (Kershaw); Hoddle Range (J. Searle); Healesville (Brown); Belgrave (C. Oke); Olinda (self).

Obs.—This form is slightly taller, more tightly wound, and finer in sculpture than typical *fordei*, but nevertheless the writer is inclined to follow previous authors in regarding it as a variety only. Throughout the Dandenongs it is frequently seen, being generally located under stones. Cox and Hedley (loc. cit.) state that the type, which has been presented by the author to the Australian Museum, measures maj. diam., 7·5; min., 6; alt., 5·5 mm. This shows a slight discrepancy with the dimensions in the original description.

Family FLAMMULINIDAE.

Genus *Flammulina*, von Martens, 1873.

FLAMMULINA EXCELSIOR, Hedley.

1896. *Flammulina excelsior*, Hedley, Rec. Aust. Mus., ii, p. 103,
 pl. 23, figs. 2-4.
 1912. Id., Cox and Hedley, Mem. Nat. Mus. Melb., No. 4, p. 11.
 1929. Id., Gabriel, Vic. Nat., xlvii (6), p. 132.

Size of Type.—Maj. diam., 9; min., 8; alt., 6 mm.

Localities.—Victoria (Sir W. B. Spencer); Cann River (Nat. Mus., Melb.), collected by J. Clark.

Obs.—The author remarks: "This very fragile shell of a group hitherto unrecorded from Australia seems in shape to be nearest allied to *F. cornea*, Hutton, from Auckland, New Zealand, from which its size, colour and perforation distinguish it. In a bottle with *Cystopelta*, but without locality more precise than "Victoria," Prof. W. Baldwin Spencer has sent me examples of this species in spirits."

Again, in 1912, in collaboration with the late Dr. J. C. Cox, Mr. Hedley remarks: "It is likely that the unlocalized Victorian specimen obtained by Professor Spencer, and referred to in the original description, came from some neighbouring alpine district." A characteristic feature is the angular brown flames of irregular pattern. Type in Australian Museum, Sydney, from Mt. Kosciusko.

Family ZONITIDAE.

Genus **Helicarion**, Ferussac (em.), 1821.**HELICARION** CUVIERI, Ferussac.

1821. *Helicarion cuvieri*, Ferussac, *Tabl. Syst.*, p. 20.
 1832. *Vitrina nigra*. Quoy and Gaimard, *Voy. Astrolabe*, Zool., Moll. ii, p. 135, pl. 11, figs. 8, 9.
 1850. *Vitrina verreauxi*, Pfeiffer, *P.Z.S.* for 1849, p. 132.
 1862. Id., Reeve, *Conch. Icon.*, xiii, pl. 4, fig. 21.
 1868. Id., Cox, *Mon. Aust. Land Shells*, p. 83, pl. 14, figs. 14, 14a.
 1870. *Helicarion cuvieri*, Semper, *Reis in Philipp.*, iii, p. 31, pl. 3, figs. 7a,b; pl. 6, fig. 11.
 1882. *Vitrina nigra*, Q. and G. Tate, *T.R.S.S.A.*, iv, p. 75.
 1891. *Helicarion verreauxi*, Pfr. Hedley, *P.L.S. N.S.W.* [2], vi, p. 24, pl. 2, figs. 10-12; pl. 3, fig. 4.
 1909. *Helicarion cuvieri*, Ferussac. Petterd and Hedley (loc. cit.), vii, p. 301.
 1921. Id., May, *Check-List Moll. Tas.*, p. 97, No. 945.
 1923. Id., May, *Ill. Index Tas. Shells*, pl. 43, fig. 26.

Size of Average Specimen.—Diam., 11; alt., 6.5 mm.

Localities.—W. Port (Astrolabe); Fernshaw, Sale and Cape Otway (Petterd); Jumbunna (Kitson); Mallacoota (C. L. Barrett); Mornington (Rev. G. Cox); Bairnsdale (Nat. Mus.); Lorne (self); Lillypilly Gully, Wilson's Promontory (E. S. Hanks).

Obs.—Reeve says: "Distinguished chiefly by its narrowly produced transverse form." It is a frequent species, which appears to prefer damp conditions under decayed timber. Examples from the last-named locality are much darker than typical specimens, approaching chocolate brown. It extends to Tasmania, the largest coming from the extreme south.

HELICARION VIRENS, Pfeiffer.

1849. *Vitrina virens*, Pfeiffer, *P.Z.S. Lond.*, p. 108.
 1862. Id., Reeve *Conch. Icon.*, xiii, pl. 3, fig. 14.
 1868. Id., Cox, *Mon. Aust. Land Shells*, p. 85, pl. 14, figs. 5, 5a.
 1885. *Helicarion virens*, Pfr. Tryon, *Man. Conch.*, i, p. 172, pl. 39, figs. 69-71.
 1888. Id., Hedley, *P.R.S. Qld.*, v, (2), p. 49.

Size of Type.—Diam., 16; alt., 8 mm.

Locality.—Lakes Entrance (T. Worcester).

Obs.—A rather dull, greenish-olive shell, with little indication of striae. It is recorded from Clarence River, N.S. Wales (Dr. Cox), and Moreton Bay, Queensland (Hedley).

Genus **Microcystis**, Beck, 1837.**MICROCYSTIS** CIRCUMCINCTA, Cox.

1864. *Helix marmorata*, Cox, *Ann. Mag. Nat. Hist.* [3], xiv, p. 182 (non Ferussac).
 1864. Id., *Cat. Aust. Land Shells*, p. 20.

1868. *Helix circumcincta*, Cox, Mon. Aust. Land Shells, p. 3, pl. 5, figs. 6a, b.
 1886. *Nanina marmorata*, Cox. Tryon, Man. Conch., ii. p. 105, pl. 35, figs. 39, 40.
 1888. Id., Hedley, P.R.S. Qld., v (2), p. 50.
 1903. *Rhytida* (*Macrocyclus*) *circumcincta*, Cox. Moellendorff and Kobelt, Conch. Cab. (Agnatha), p. 56, pl. 10, figs. 9-11.
 1912. *Microcystis marmorata*, Cox. Hedley, P.L.S. N.S.W., xxxvii, p. 262.
 1917. Id., Odhner, K. Sv. Vet. Ak. Handl., lii (16), p. 78, figs 30a, 31 (in text).

Size of Type.—Major diam., 10·15; min., 8·6; alt., 5·57 mm.

Locality.—Lakes Entrance (T. Worcester).

Obs.—A minutely perforated species bearing a general resemblance to *Nanina jacksoniensis*, Gray, which, however, is said to be imperforate. This is not an uncommon species in New South Wales, extending as far north as the Hunter River. Hitherto unrecorded for Victoria.

Genus *Cystopelta*, Tate, 1881.

CYSTOPELTA PETTERDI, Tate.

1881. *Cystopelta petterdi*, Tate, P.R.S. Tas., 1880, p. 17.
 1890. Id., Hedley, P.L.S. N.S.W. [2], v, p. 44, pl. i.
 1891. Id., Hed., loc. cit. vii, p. 24, pl. 3, fig. 5.
 1896. Id., Hed., Rec. Aust. Mus., ii. p. 102.
 1909. Id., Hedley and Petterd, Rec. Aust. Mus., vii, p. 292.
 1912. Id., Cox and Hed., Mem. Nat. Mus. Melb., No. 4, p. 10.

Localities.—Ballarat (Musson); Loch (Frost); Baw Baws (J. Searle).

Obs.—A genus without a shell. This was once placed in the Limacidae. Later, Tryon chose Tebennophoridae, while Hedley's classification is Fam. Zonitidae; Sub-fam. Helicarionae; gen. *Cystopelta*.

CYSTOPELTA PETTERDI, Tate, var. *PURPUREA*, Davies.

1912. *Cystopelta petterdi*, Tate, var. *purpurea*, Davies, P.R.S. Vic. (n.s.), xxiv (2), p. 331, pls. 64-69.

Localities.—Beech Forest; Fernshaw; Narbethong.

Naturalized Land Mollusca found in Victoria.

References.—Musson, P.L.S. N.S.W. [2], v, 1890, pp. 883-896; Woodward, Journ. Conch., x, 1903, pp. 352-367; Cox and Hedley, Mem. Nat. Mus. Melb., No. 4, 1912, p. 14; Gabriel, Vict. Nat., xlv (6), 1929, p. 133.

LIMAX MAXIMUS, Linné.

"A large slug, colour varying from ash to yellowish-grey, or sometimes black; often streaked or spotted with white or black; much wrinkled. Size: 4 to 6 inches long."

LIMAX FLAVUS, Linné.

"A yellowish slug; tessellated with white, and black, or dark brown, coarsely tuberculated, very variable, as are all these creatures; keeled towards the tail, which is pointed. Size: $2\frac{1}{2}$ to 4 inches long."

AGRIOLIMAX AGRESTIS, Linné.

"A common slug; usually ash-grey, rufous, yellowish, cream colour, or whitish, often mottled; with a short keel at the tail; shell internal, consisting of a calcareous plate, such as all the Limaces have. Size: $1\frac{1}{2}$ to 2 inches long."

MILAX GAGATES, Draparnaud.

"A very variable slug; black, slate colour, dark-red, brown or yellowish, with dusky markings, pale underneath, acutely keeled from mantle to tail, shell internal. A small calcareous plate. Size: $1\frac{1}{2}$ to $2\frac{1}{2}$ inches long."

VITREA CELLARIA, Muller.

A flat, pale yellowish shell, very shining, nearly smooth; umbilicated. Widespread and frequently found in glass houses. Size: diam., 8 mm.

ZONITOIDES NITIDUS, Muller.

A small, flattish, horny shell. Size: diam., 5 mm.

HELICELLA CAPERATA, Montagu.

A brownish shell, banded, with regular close-set raised wrinkles; body whorl slightly angulated at the periphery; very abundant at many parts of our coast-line. Size: diam., 9 mm.

HELICELLA (COCHLICELLA) BARBARA, Linné.

= *Cochlicella acuta*, Muller.

A turreted-conical shell, white, with brown bands, encircling the whorls. Extremely common in flower gardens. Size: $\frac{1}{2}$ inch long.

HELIX PISANA, Muller.

A whitish shell, with numerous more or less interrupted linear coloured bands on the larger whorls; mouth moderately large, usually pink edged. Size: diam., $\frac{3}{4}$ inch.

HELIX ASPERSA, Muller.

A fawn coloured shell, with brown bands. The common "garden snail." Size: diam., 1 to $1\frac{1}{2}$ inch.

HYALINA (EUCONULUS) FULVA, Muller.

A minute shell, yellowish horn-colour, smooth, shining, spire elevated, almost imperforate. Only recorded from the Cann River district. Size: maj. diam., 2.8; alt., 2.2 mm.

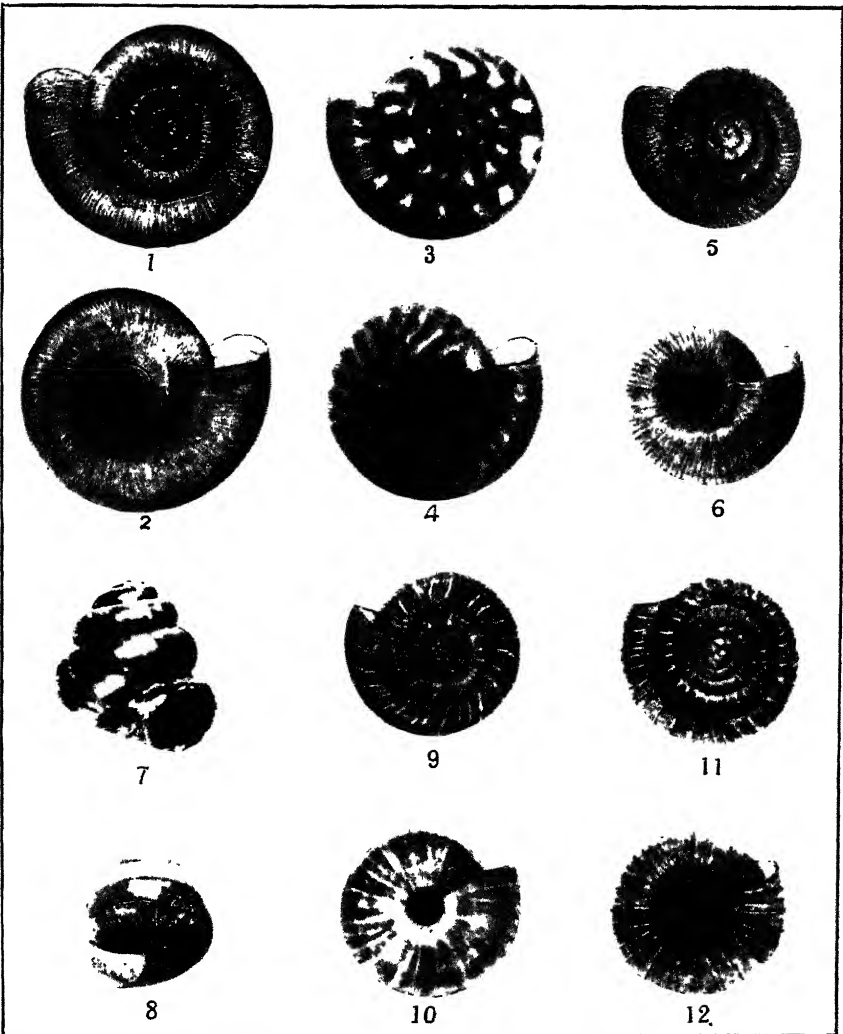
Explanation of Plates.

PLATE II.

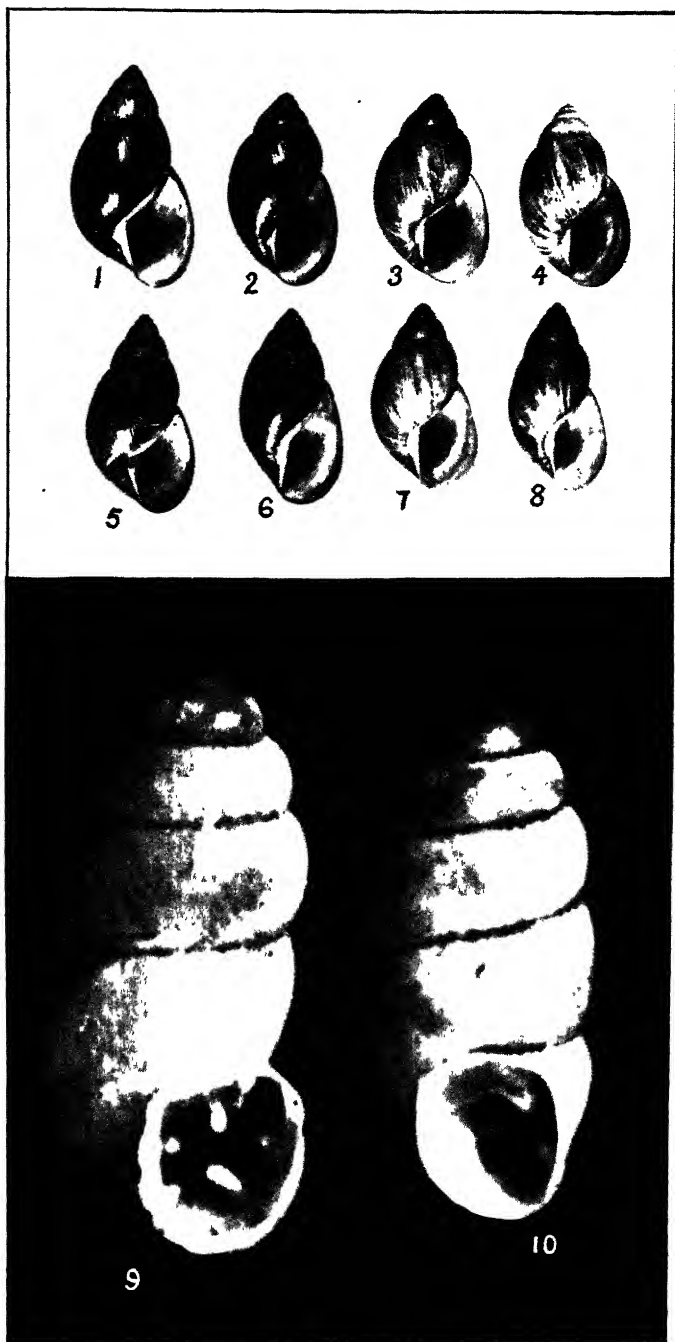
- Figs. 1, 2.—*Charopa erskinensis*, sp. nov. $\times 13$.
 „ 3, 4.—*Charopa gatliffi*, sp. nov. $\times 9$.
 „ 5, 6.—*Charopa tarravillensis*, sp. nov. $\times 9$.
 Fig. 7.—*Laoma turbinuloidea*, sp. nov. $\times 10$.
 „ 8.—*Laoma sinistra*, sp. nov. $\times 20$.
 Figs. 9, 10.—*Charopa scindocataracta*, sp. nov. $\times 17$.
 „ 11, 12.—*Charopa bairnsdalensis*, sp. nov. $\times 12$.

PLATE III.

- Figs. 1-8.—*Hedleyella atomata*, Gray, var. *kershawii*, Brazier.
 $\times \frac{1}{2}$.
 Fig. 9.—*Bifidaria bannertonensis*, sp. nov. $\times 30$.
 „ 10.—*Bifidaria bannertonensis*, sp. nov. Paratype, $\times 30$.



Victorian Land Shells



Victorian Land Shells

ART. VII.—*Notes on Australian and New Zealand Foraminifera.*
No. 1.—The Species of Patellina and Patellinella, with a
Description of a new Genus, Annulopatellina.

By WALTER J. PARR, F.R.M.S., and ARTHUR C.
COLLINS, A.R.V.I.A.

(With Plate IV.)

[Read 10th July, 1930; issued separately 29th September, 1930.]

Introduction.

The object of this series of papers is to review the species of foraminifera found living and fossil in the Australian and New Zealand region. It is proposed to deal with one or more related genera in each paper.

The foraminifera of the Indo-Pacific area are of especial interest. Many of the species of the Eocene of the Paris Basin are found in the Oligocene and Miocene of Victoria, and some, or closely related forms, are still living on the Australian coast and elsewhere in the shallower waters of the Indian and Pacific Oceans. The Miocene faunas of Austria and Hungary are also represented here, while, as Dr. J. A. Cushman has recently pointed out, the living fauna of the Caribbean and West Indian region is much more like that of the Australian region than any other.

With the exception of *Patellina*, the genera now studied are confined to the Indo-Pacific. The genus *Patellina* has recently been the subject of a paper by Cushman (1930, pp. 11-17, pl. iii), to which the present notes may be regarded as supplementary. *Patellinella* is known by a single species, *P. inconspicua* (Brady), and has been considered by some authors to be unrelated to *Patellina* or to other genera of the Rotaline group. The discovery of a more primitive species of *Patellinella*, showing without doubt that *Patellinella* has evolved from *Patellina*, is therefore of great interest. The third genus is a new one which we have erected to receive *Orbitolina annularis* Parker and Jones, a species common in South Australian waters, which differs in several important points from the true *Orbitolinae* and *Patellinae* with which it has been grouped.

For much help in the form of material from the important localities of Europe and elsewhere, and valuable advice, we are indebted to our friend, Mr. Frederick Chapman, A.L.S., etc., the Commonwealth Palaeontologist. We are also under obligations to Dr. J. A. Cushman, of Sharon, U.S.A., for his assistance.

Description of Species.

Genus *Patellina* Williamson, 1858.*PATELLINA CORRUGATA* Williamson.

(Plate IV, Figs. 1-5.)

Patellina corrugata Williamson, 1858, p. 46, pl. iii, figs. 86-89.
 Chapman, 1909b, p. 354; 1915, p. 28; 1916, pp. 338, 359, 377.
 Heron-Allen and Earland, 1922, p. 198, pl. vii, fig. 5.

Description.—Test spiral, trochoid, concave inferiorly, early whorls usually undivided, later whorls consisting of long crescentic chambers, about two to the whorl, divided into chamberlets by septa; septa of varying length, sometimes in alternating series of two or more orders, arising from the peripheral margin of the chamber, and stopping short of the inner margin, where all the chamberlets communicate; umbilical area filled by an exogenous growth of shelly material in which there are thickened ridges arranged in an irregularly coiled pattern; aperture not visible; wall calcareous, hyaline, perforate.

Diameter.—0.3-0.4 mm.

Observations.—Cushman has suggested that the species of *Patellina* present in the Indo-Pacific region is *P. advena* Cushman, a species described from the Lower Oligocene (Mint Spring Calcareous Marl), Mint Spring Bayou, Vicksburg, Miss., U.S.A. We have examined a large series of specimens, both fossil and recent, from Australia and New Zealand, and after comparing them with examples of *P. corrugata* from the British Isles, are of the opinion that they are identical with Williamson's species. There is some variation in the degree of fineness of the secondary septation. Three examples illustrating this, from the one dredging, are figured on Plate IV. Fig. 2 represents a megalospheric specimen. This is coarsely subdivided as in the examples of *P. corrugata* at hand from the British Isles. Fig. 4 is a microspheric example, very finely subdivided. It agrees with one we have, through the kindness of Dr. Cushman, from the Lower Oligocene (Byram Marl), of Leaf River, Miss., U.S.A., which is apparently *P. advena*. Our specimens are connected by an intermediate form, with a smaller proloculum than Fig. 2, but larger than Fig. 4. This is represented by Fig. 3. Apparently we have here an example of what Hofker (1925, pp. 68-70) has termed trimorphism.

In our material there are examples with fewer chambers than usual. Similar specimens were met with by Cushman in his New Zealand collections, in company with *P. advena*. This character is also found in some of the British specimens of *P. corrugata*. The finding of the peculiar oval form of *Patellina* figured by Heron-Allen and Earland in their paper (1913, p. 109, pl. ix, fig. 11) on Clare Island foraminifera, in the dredging from off the Snares, S. of New Zealand, with typical *P. corrugata* and the

forms recorded by Cushman appears to be evidence that our identification of *P. corrugata* is correct. Heron-Allen and Earland regarded this oval form as being the microspheric stage of *P. corrugata*, with which it occurred. Our example is definitely megalospheric (Plate IV, fig. 5), and as it here also occurs with *P. corrugata*, it may prove to be a variety of that species, when more material is available. This oval form suggests the relationship of *Patellina* to *Patellinella*, which is brought out by a new species of the latter genus, which we describe below.

Occurrence.—Recent: dredgings, Geraldton Harbour, Western Australia; Bass Strait, off Gabo Island; E. of Tasmania, 1320 fms.; E. of Cape Saunders, Otago, N.Z., 40-50 fms.; off the Snares, S. of N.Z., 60 fms. Lower Pliocene (Kalinman): Mallee Bores. Miocene (Janjukian); Mallee Bores. Oligocene (Balcombian): Balcombe Bay, Mornington; Kackeraboite Creek; and Muddy Creek, near Hamilton, Victoria.

Genus **Patellinella** Cushman, 1928.

PATELLINELLA ANNECTENS, sp. nov.

(Plate IV, Fig. 6.)

Description.—Test subconical, depressed, trochoid, about $1\frac{1}{2}$ times as long as broad, consisting of a small proloculum, followed by a short undivided coiled series, remaining chambers also undivided, arranged two to the whorl; sutures distinct, flush; wall calcareous, coarsely perforate; aperture at the base of the last-formed chamber. Length, 0.32 mm.; breadth, 0.25 mm.; height, 0.14 mm.

Holotype (Parr and Collins Coll.) from Oligocene (Balcombian), Muddy Creek, near Hamilton, collected by W. J. Parr.

Observations.—This is a particularly interesting species, showing, as it does, the relationship between the genera *Patellina* and *Patellinella*, which is clearly brought out by the figures of the two genera. It resembles *Patellina* in having the early portion of the shell coiled. It has also a similar deposit of shell substance on the under surface, formed by each chamber, and in this species extending as a thin lamina more than halfway across the inferior surface, that of each pair of chambers forming what may be described as a roughly sigmoidal depression, at the base of the last-formed portion of which lies the aperture. That it is a true *Patellinella* is shown by the lateral compression of the test, the textularian plan of growth, and the undivided character of the chambers. As might be expected from its appearance in the Oligocene, it is a more primitive form than *P. inconspicua*, which appears for the first time in the Post-Tertiary of Victoria.

Occurrence.—Oligocene (Balcombian): Muddy Creek, near Hamilton, Victoria.

PATELLINELLA INCONSPICUA (Brady).

(Plate IV, Fig. 7.)

Textularia inconspicua Brady, 1884, p. 357, pl. xlii, fig. 6a-c. Millett, 1899, p. 557, pl. vii, fig. 1.

Discorbis inconspicua (Brady): Cushman, 1919, p. 626.

Textularia inconspicua Brady: Heron-Allen and Earland, 1922, p. 116.

Patellinella inconspicua (Brady): Cushman, 1928, p. 5, pl. i, fig. 8a-c.

Observations.—This species was recorded by Brady from three "Challenger" stations in the Pacific, off East Moncoeur Island, Bass Strait; Nares Harbour, Admiralty Islands; and the *Hyalonema* ground, S. of Japan. Millett's examples from the Malay Archipelago are lower and more outspread than the specimen figured by Brady, which was from Bass Strait. Subsequent records are those of Cushman from off New Zealand, and Heron-Allen and Earland from the same area. The species is also known from the Kerimba Archipelago, off Portuguese East Africa.

Our specimens are all typical. The figured example, from the Post-Tertiary of Victoria, is an exceptionally large one, with strongly limbate sutures. The species seems to be subject to little variation, as examples from a depth of 1320 fms. agree in every respect with those from shallow water.

Occurrence.—Recent: shore sand, Point Lonsdale; Torquay; Port Fairy, Victoria; dredgings, E. of Tasmania, 1320 fms. Post-Tertiary: boring near Boneo, Victoria, 177-187 ft.

Annulopatellina, gen. nov.

Description.—Test depressed conical, concave on the inferior side, consisting of a globular proloculum, which is wholly or partly embraced by a crescentic to subcircular second chamber; remaining chambers annular and with the exception of the first two or three, always subdivided into chamberlets, which extend inwards on the under surface of the test in the form of tubular prolongations closed at the ends and sometimes anastomosing; wall calcareous, hyaline, perforate, thin; aperture apparently absent.

Observations.—This genus has been erected for the reception of Parker and Jones's *Orbitolina annularis*, which was later transferred to the genus *Patellina* by Carpenter. This species resembles *P. corrugata* and other typical species of the same genus in its depressed plano-convex test, and in the subdivision of the chambers, but its plan of growth is quite distinct. Instead of being built on a rotaline plan, with two or three chambers to the whorl, as in *P. corrugata*, the chambers are, with the exception of the proloculum and the following chamber, annular. The early undivided coils of *P. corrugata* are also absent from *A. annularis* in both megalospheric and microspheric forms. Further notes on the points of difference between the two genera will be found in the notes on *A. annularis*.

ANNULOPATELLINA ANNULARIS (Parker and Jones).

(Plate IV, Figs. 8, 9, 10.)

Orbitolina annularis Parker and Jones, 1860, pp. 30, 31.*Patellina corrugata* Williamson: Carpenter (*pars*), 1862, p. 230, pl. xiii, figs. 16, 17.*Patellina annularis* (Parker and Jones): Parker and Jones, 1865, p. 438.*Patellina corrugata* Chapman (*non* Williamson), 1909A, p. 134, pl. x, fig. 7.*Patellina corrugata*, var. *annularis* (Parker and Jones): Heron-Allen and Earland, 1922, p. 198.

Description.—The characters of the species are those of the genus.

Dimensions.—Diameter up to 1.2 mm.; height to 0.25 mm.

Observations.—This species was originally described from Australian shore sands, and the remainder of the records, with the exception of a somewhat doubtful one by Heron-Allen and Earland from off New Zealand, are all from the Australian coast. It is not known as a fossil.

Our own records are all from Australian waters, over an area extending from Geraldton, Western Australia, along the southern coast to as far east as Gabo Island. The specimens fall into two groups, one consisting of those with a large proloculum, followed by an undivided crescentic chamber, and then an annular series of up to twelve chambers, and the other, of much larger specimens, with a small proloculum, embraced by a kidney-shaped to subcircular chamber, subdivided into chamberlets, and followed by a greater number, up to as many as sixteen, annular chambers. The two groups clearly represent the megalospheric and microspheric forms of the species. The diameter of the proloculum of a megalospheric example measures 0.07 mm., and that of a microspheric specimen, 0.015 mm. The degree of fineness of the subdivisions of the annular chambers varies considerably, but not according to whether the specimen is megalospheric or microspheric. Plasmogamy occurs in *A. annularis*, particularly in the material from Hardwicke Bay, South Australia, in which the paired shells and others which had become disunited are quite common. In every such case, it was found that most of the base and the whole of the septa had disappeared, having been absorbed in the process of reproduction.

Reference has already been made to the subdivision of the chamber surrounding the proloculum in the microspheric form. The number of these chamberlets is very variable, and it is difficult to determine just what their nature is. In one example, the apex of which is figured (fig. 10), they are undoubtedly similar to those in the later annular series. In others, including that figured by Mr. Chapman (*loc. cit. supra*), which he has kindly allowed us to examine, they have curved septa in a few, sometimes only one, of the chamberlets, which therefore seem to be of a rotaline

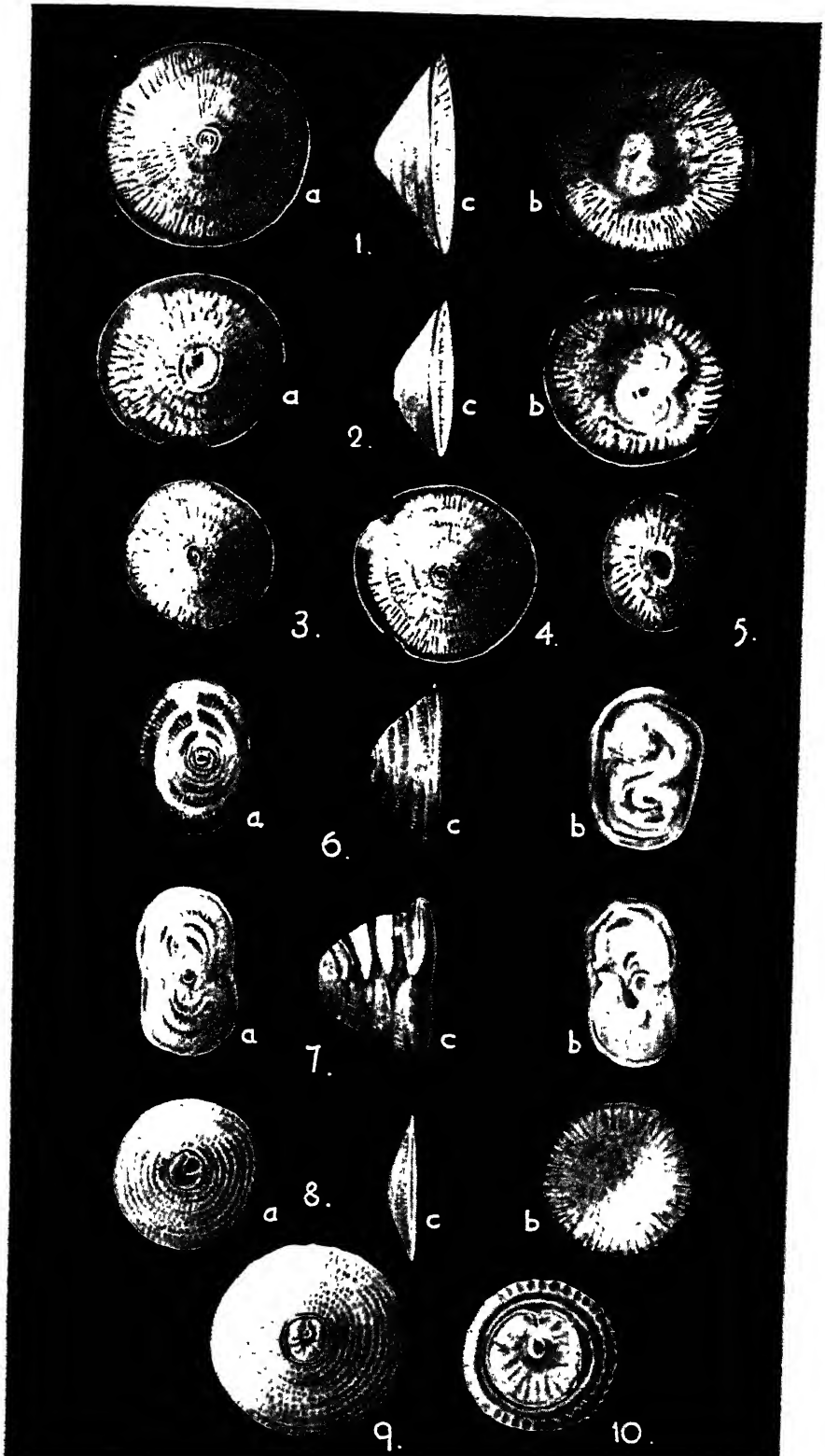
nature, although it should be stated that, to us, the outer septal face of some of these chamberlets appears concave or flat, not convex, as one would expect to find in a rotaline form. It was intended to figure several of these chamberlets, but an unfortunate accident resulted in the destruction of the specimens selected for figuring.

In the absence of anything definite regarding the nature of the early chamberlets in the microspheric form, the affinities of the genus remain obscure. When recording this species (as *Patellina corrugata*, var. *annularis*) from the "Terra Nova" dredgings, off New Zealand, Heron-Allen and Earland note the occurrence of other specimens representing transition stages between it and *P. corrugata*. No such specimens have been met with by us, the characters of *A. annularis*, judging by the plentiful material at our disposal, being very constant. If it is related to *Patellina*, the ontogeny of the microspheric form should provide evidence of the relationship, but this is lacking. The only point of resemblance is the subdivision of the chambers. More examples of the rather rare microspheric form are needed to clear up this interesting problem.

Occurrence.—Dredgings, Geraldton Harbour, Western Australia; shore sand, Hardwicke Bay; Glenelg, South Australia; Torquay; Point Lonsdale, Victoria; dredgings, off Gabo Island, Bass Strait.

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A.C.C. ad nat. del.

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Explanation of Plate IV.

(a, dorsal view; b, ventral view; c, side view.)

- Fig. 1a-c.—*Patellina corrugata* Williamson. Oligocene (Balcombian). Lower Beds, Muddy Creek, near Hamilton, Victoria. $\times 60$.
- Fig. 2a-c.—*P. corrugata* W'mson. Megalospheric form. Dredgings off Gabo Island. $\times 60$.
- Fig. 3.—*P. corrugata* W'mson. Intermediate megalospheric form. Dredgings off Gabo Island. $\times 60$.
- Fig. 4.—*P. corrugata* W'mson. Microspheric form. Dredgings off Gabo Island. $\times 60$.
- Fig. 5.—*P. corrugata* W'mson., oval var. Dredgings off the Snares. S. of New Zealand. $\times 60$.
- Fig. 6a-c.—*Patellinella annectens*, sp. nov. Oligocene (Balcombian). Lower Beds, Muddy Creek, near Hamilton, Victoria. $\times 80$.
- Fig. 7a-c.—*P. inconspicua* (Brady). Post-Tertiary. Bore near Boneo, Victoria, 177-187 feet. $\times 60$.
- Fig. 8a-c.—*Annulopatellina annularis* (Parker and Jones). Megalospheric specimen. Shore sand, Glenelg, South Australia, $\times 50$.
- Fig. 9.—*A. annularis* (P. & J.). Microspheric example, Shore sand, Glenelg, South Australia. $\times 50$.
- Fig. 10.—*A. annularis* (P. & J.). Apical chambers of Fig. 9. $\times 100$.

ART. VIII.—*Rare Foraminifera from Deep Borings in the
Victorian Tertiaries.*

Part II.

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(With Plate V.)

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In continuation of our former paper on "Rare Foraminifera from Deep Borings in the Victorian Tertiaries," under the auspices of the Commonwealth Government, the following series of new forms from the East Gippsland Area is described. Most of these are affording valuable evidence in the discrimination of zones, especially in the older part of the Tertiary Series, and in the main are restricted to the Gippsland area.

Genus *Cyclammina* H. B. Brady, 1876.

CYCLAMMINA ROTUNDATA, sp. nov.

(Plate V, Figs 1, 2.)

Haplophragmoides latidorsatum (non Born.) Chapman, 1904, p. 227, pl. xx, fig. 1.

Description of Holotype.—Test subglobular, depressed in umbilical area; peripheral margin, especially in later portion, well rounded, about 8 sutures visible on the last whorl. Aperture a narrow arched slit at base of the septal face, with cancellation on the surface. Aperture always more or less oblique. Shell texture moderately finely arenaceous, colour varying from white to grey.

Dimensions.—Greatest diameter of test, 1.4 mm.; greatest width, 0.82 mm.

Paratype.—From 1165 ft. No. 1 Bore, Parish of Bumberrah (Metung), shows a less depressed umbilical area, and coarser arenaceous structure.

Observations.—The specimen figured previously by one of us from the ochreous clay from Brown's Creek, Otway Coast (loc. supra cit.), is here regarded as a species of *Cyclammina*, the type specimen of which was obtained from deep borings in Gippsland. In the first place it differs from *Haplophragmoides latidorsatum* of authors later than Bornemann, and also from *Haplophragmoides*

subglobosum of Sars, by the less inflated chambers and the cancellated structure of the test. *Cyclammina rotundata* is less depressed than *C. incisa* (Stache), and is generally a smaller form with fewer chambers. It is often accompanied by *C. incisa*.

Occurrence.—No. 1 Bore, Parish of Bumberrah (Metung) at 1165, 1240, and 1295 feet; No. 3 Bore, Darriman at 1189 feet; No. 5 Bore, Parish of Glencoe, at 430 feet.

CYCLAMMINA LONGICOMPRESSA, sp. nov.

(Plate V, Figs. 3, 4.)

Description of Holotype.—Test spiral, ovately lengthened towards the termination of the last whorl. Surface somewhat compressed, whorls involute with a small umbilical depression. Chambers few, about 7 in the whorl. Sutures not deeply impressed; periphery sub-acute, aperture narrow; arched slit, rather oblique, the last chamber has a flat septal face; colour generally white; structure arenaceous, with a medium texture.

Dimensions.—Longest diameter of holotype, 2 mm.; shortest diameter, 1.3 mm.; thickness of test, 0.86 mm.

Observations.—This form of *Cyclammina* might be regarded as a distorted variety of *C. incisa*, but for the fact that it appears to be a constant form in the deep parts of the borings in the Victorian Tertiaries. It has also been met with in the Brown's Creek material from the Aire Coast.

Occurrence.—No. 4 Bore, Parish of Glencoe at 230 feet, and in No. 5 Bore at 486 feet; No. 3 Bore, Parish of Darriman, at 1207 feet; also from Brown's Creek, Aire Coast.

Genus *Lingulina* d'Orbigny, 1826.

LINGULINA BARTRUMI Chapman var. METUNGENSIS, nov.

(Plate V, Fig. 5.)

Lingulina bartrumi Chapman, 1926, p. 54, pl. xi, figs. 12a,b.

Description of Holotype.—Test broadly ovate, bluntly pointed at extremities, compressed at the sides and on the distal margin of the last chamber. Segments number four, the height of the last almost equal to the previous three. Surface of chambers delicately striate. Aperture is a short slit-like orifice at the apex of the last chamber.

Dimensions.—Length of test, 4.8 mm.; greatest breadth, 1.5 mm.; height of last chamber, 1.18 mm.

Observations.—This variety resembles the New Zealand species *L. bartrumi* in its general characters, but there are varietal differences which make it necessary to refer to it as a variety. The differences seen in the Metung specimens consist in the wider chambers, in the more arched sutures, and greater compression of the border of the last chamber. The type series from New Zealand

occurred in the Upper Eocene grey marls at Weka Creek; in the Oligocene of Waikato South Head; North Head, Kaawa Creek; and south of Port Waikato.

Occurrence.—No. 1 Bore, Parish of Bumberrah (Metung), at 895 and 1320 feet.

Genus *Vaginulina* d'Orbigny, 1826.

VAGINULINA GIPPSLANDICA, sp. nov.

(Plate V, Fig. 6.)

Description of Holotype.—Test linear, elongate, slightly curved, marginuline in general form but strongly compressed. Proloculum rounded, half enclosed by the second chamber; the ten succeeding chambers low and more or less oblique. Surface of test ornamented with a series of strong partially interrupted costae, about 11 showing on each side of the penultimate chamber, the last chamber somewhat inflated and nearly smooth. Aperture sub-circular situated on the concave side of the test at the end of a short spout-like prolongation. The above extremity terminates in a short blunt spinous process.

Dimensions.—Length, 4.2 mm.; greatest width, 1.04 mm.

Observations.—This species is quite a typical form in the lower part of the Tertiary series in the borings in Gippsland. The characters of the species are fairly constant. In ornament it bears certain resemblance to the *Marginulina costata* type, and in general shape with that of *Vaginulina legumen*. The compression of the test shows it to belong to the genus *Vaginulina*. A somewhat related form is the *Marginulina asprocostulata* (Stache, 1864, pl. xxii, fig. 53), but our species differs in being elliptical in section and in having the costulation finer, more oblique and somewhat interrupted.

Occurrence.—No. 3 Bore, Parish of Darriman, at 1189 feet; Parish of Glencoe, No. 3 Bore, at 180 feet, 190 feet, 200 feet and 210 feet; No. 4 Bore, at 240 feet and 260 feet, and No. 5 at 450 feet; No. 1 Bore, Parish of Bumberrah (Metung), at 1180 feet, 1240 feet and 1320 feet. The species will apparently prove a good zonal fossil since at present it occurs only in the basal beds of the Tertiary series proved by the bores in Gippsland.

Genus *Carpenteria* Gray, 1858.

CARPENTERIA ROTALIFORMIS, sp. nov.

(Plate V, Figs. 7, 8.)

Carpenteria proteiformis Goës (*pars*): Chapman, 1913, p. 171, pl. xvi, fig. 7.

Description of Holotype.—Test suborbicular, convex on one side, somewhat flattened on the opposite. The aperture occurs in the periphery. Point of attachment very small, usually on the flattened surface. Test consists of a rudely coiled system about 5 chambers. Surface papillate.

Dimensions.—Width of holotype, 1.7 mm.; height, 1.3 mm.

Observations.—The figured specimen from the Mallee borings referred to above (Paratype in National Museum, No. 12428) undoubtedly belongs to this varietal form. At the time it was remarked upon as follows:—"The specimens from the polyzoal rock of the Mallee borings are invariably arrested in growth, showing only the first tier of segments above the primordial group."

Occurrence.—No. 3 Bore, Parish of Darriman at 939, 1079 and 1109 feet; Parish of Glencoe, Bores No. 2 at 813 feet, No. 3 at 180 feet; No. 4 at 158-160 and 240 feet, No. 5 at 150 feet; No. 1 Bore, Parish of Bumberrah (Metung) at 984, 1020 and 1040 feet. In the Mallee it occurred in Bore 11 at 540-542 feet; 544-546 feet and 560-562 feet.

CARPENTERIA ALTERNATA, sp. nov.

(Plate V, Figs. 9, 10.)

Description of Holotype.—Test conoidal, chambers sub-globular, sometimes depressed increasing in size from the apical attached surface and arranged in a more or less alternating series, sutures deeply impressed. Surface of test moderately smooth. Aperture crescentic to sub-circular, partially surrounded by a neck-like process. The aboral extremity usually concave, indicating an impressed surface of attachment. Another specimen figured (Paratype) shows a similar alternating series, but with the test more generally compressed.

Dimensions.—Length of holotype, 1.8 mm.; greatest width, 1.5 mm.

Observations.—In the structure of the shell this species resembles *Carpenteria proteiformis*, but the constant character of a series of specimens enables us to separate these short forms with a textularian growth from the latter species.

Occurrence.—No. 5 Bore, Parish of Glencoe, at 150 feet.

Genus *Lamarckina* Berthelin, 1881.

LAMARCKINA GLENCOENSIS, sp. nov.

(Plate V, Figs. 11, 12).

Description of Holotype.—Test elongate ovate. Superior face flattened. Whorls entirely exposed, consisting of 2 whorls, the outer one consisting of about 8 chambers and enlarging rapidly. Sutures thickened. Surface ornamented with closely set pustules. Inferior face showing about two-thirds of last whorl, surface somewhat smooth. Aperture on inferior surface wide and partially closed by a semicircular flap. Periphery of test bluntly carinate along the inner septal edge.

Dimensions.—Greatest length, 0.95 mm.; width, 0.77 mm.; greatest thickness, 0.68 mm.

Observations.—In its general form and tuberculated surface our species resembles *Lamarckina rugulosa* (Cushman, Plummer MS., 1926, p. 8, pl. iii, fig. 6a-c) with a distinction that in the latter the inner whorl does not carry so far, and no septation is visible after the first outer chamber or so. In our specimen, the limba-tion of the chambers of the inner whorl is a marked feature. *Lamarckina rugulosa* occurred in the lower Eocene of Midway, Texas and in the Clayton, Mississippi.

Occurrence.—No. 3 Bore, Parish of Glencoe at 100 feet, and No. 5 Bore at 387 feet.

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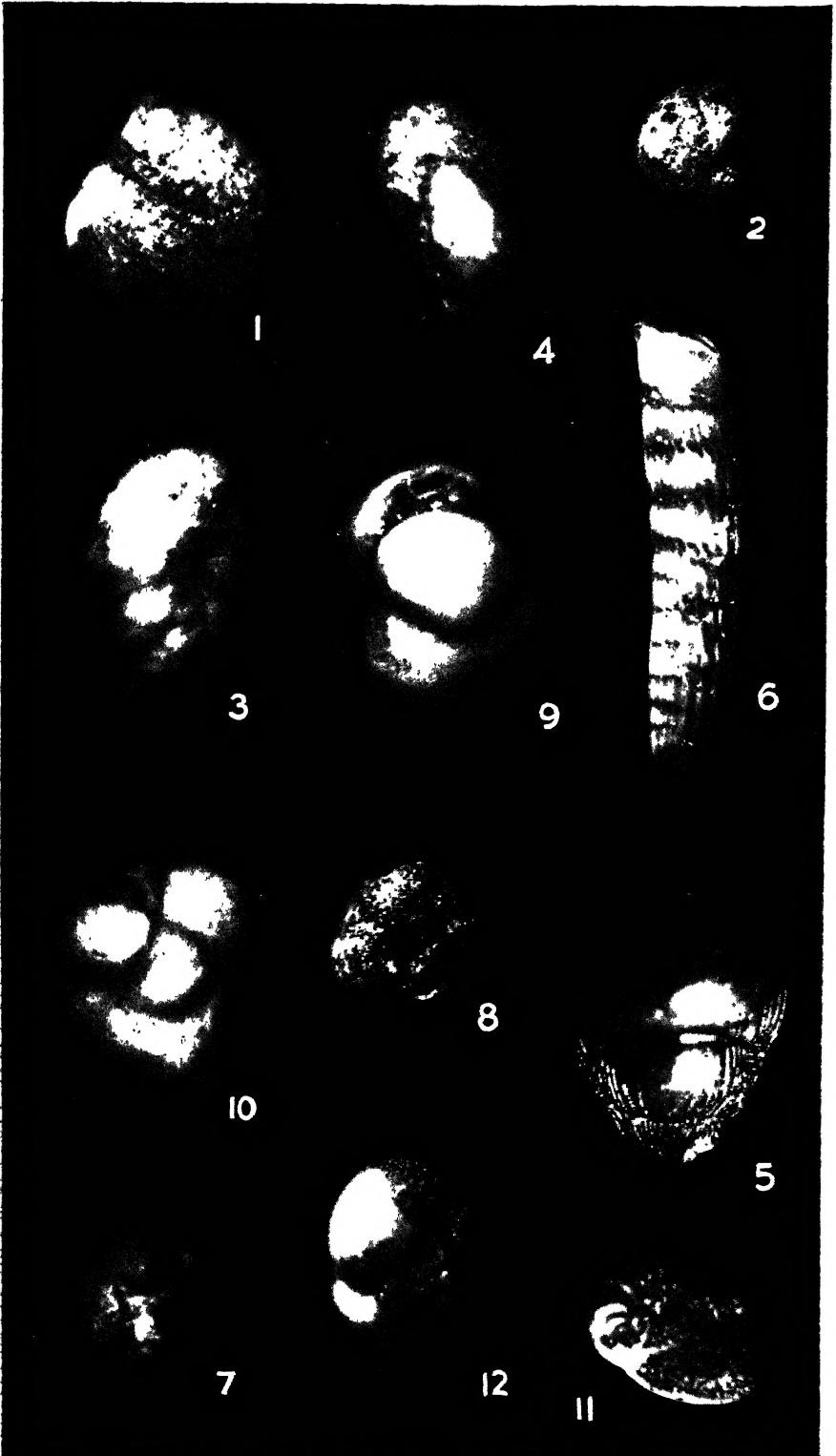
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Explanation of Plate V.

- Fig. 1.—*Cyclammina rotundata*, sp. nov. No. 1 Bore, Parish of Bumberrah (Metung), 1295 feet. Holotype. $\times 22$.
- Fig. 2.—*C. rotundata*, sp. nov. Metung, 1165 feet. Paratype. $\times 12$.
- Fig. 3.—*C. longicompressa*, sp. nov. No. 4 Bore, Parish of Glencoe, 230 feet. Holotype, lateral aspect. $\times 22$.
- Fig. 4.—*C. longicompressa*, sp. nov. No. 4 Bore, Parish of Glencoe, 230 feet. Apertural aspect of another specimen. (Paratype). $\times 22$.
- Fig. 5.—*Lingulina bartrumi* Chapman var. *metungensis*, nov. No. 1 Bore, Parish of Bumberrah (Metung), 1320 feet. Holotype, natural aspect. $\times 15$.
- Fig. 6.—*Vaginulina gippslandica*, sp. nov. No. 3 Bore, Parish of Glencoe, 180 feet. Holotype, natural aspect. $\times 14$.
- Fig. 7.—*Carpenteria rotaliformis*, sp. nov. No. 1 Bore, Parish of Bumberrah (Metung), 1020 feet. Holotype, superior surface. $\times 14$.
- Fig. 8.—*C. rotaliformis*, sp. nov. Ditto. Holotype, inferior surface. $\times 14$.
- Fig. 9.—*Carpenteria alternata*, sp. nov. No. 5 Bore, Parish of Glencoe, 150 feet. Holotype. $\times 18$.
- Fig. 10.—*C. alternata*, sp. nov. Ditto. Paratype. $\times 18$.
- Fig. 11.—*Lamarckina glencoensis*, sp. nov. No. 3 Bore, Parish of Glencoe, 1000 feet. Holotype, superior surface. $\times 28$.
- Fig. 12.—*L. glencoensis*, sp. nov. Ditto. Inferior surface of another specimen. Paratype. $\times 28$.

END OF VOLUME XLIII, PART I.

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F.C. photo.

New Foraminifera from Deep Borings in Gippsland.

